SOME ASPECTS OF THE BIOLOGY OF THE SPECKLED TROUT SALVELINUS FONTINALIS (MITCHILL) 1815, IN THE WATERS OF INSULAR NEWFOUNDLAND

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SOME ASPECTS OF THE BIOLOGY OF THE SPECKLED TROUT *SALVELINUS FONTINALIS* (MITCHILL) 1815, IN THE WATERS OF INSULAR NEWFOUNDLAND

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A B S T R A C T

Some broader aspects of the biology of speckled trout in the waters of insular Newfoundland were examined in the light of both geographic separation and variation in habitat type.

Size composition, age composition, maximum sizes attainable and growth rate were found to be dependent on habitat size, with mean size, mean age, and rate of growth increasing with increased spatial allotment

Growth of Newfoundland trout taken from small bodies of water is comparable to that of its mainland counterpart in a similar habitat; in larger bodies of water, however, mainland trout show a faster growth rate.

The length-weight relationship was determined for Newfoundland trout, and the cube law was closely followed. The ratio of weight to length reaches a maximum or optimum and then decreases as the habitat progresses in size from stream to lake. Seasonally, there is an increas in the weight to length ratio from spring to fall.

Condition factors were calculated to indicate the suitability of the different habitats. The mean condition coefficient bears a similar relationship to habitat size as the length-weight relationship. The condition factor was found to either increase or decrease with increase length, with a decrease indicating a deficiency or limitation of the environment.

Meristics were used to determine population differences due to geographical separation. Vertebral numbers followed Jordan's Rule. Gill raker number was correlated with fish size and geographical comparison was of little value. Dorsal and anal fin ray counts showed no consistent variation with fish size or latitude. There was no sexual dimorphism in meristic counts.

Male trout mature sexually at both an earlier age and smaller size than females. The relationship between egg number and size and age was examined for Newfoundland trout and compared with data for mainland trout. There was little evidence of a deviation from the 1:1 sex ratio under natural conditions.

The food of speckled trout was examined both qualitatively and quantitatively. The food includes the adults, larvae, and pupae of terrestrial insects, the larvae, adults, and nymphs of aquatic insects, amphipods, gastropods, ostracods, annelids, and forage fish. Benthic organisms are generally utilized relatively more than either pelagic or terrestrial forms. Food intake decreases from spring to fall, and forage fish, when available, form the bulk of the diet of larger trout.

Speckled trout were found to be heavily parasitized by five macroscopic forms, one of which (Salmincola sp.) has been shown to cause death. Two others (Echinorhynchus lateralis and Philonema sp.) were shown to at least cause serious injury. The known distribution of Philonema sp. and Argulus canadensis was extended.

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FRONTISPIECE: THE SPECKLED TROUT Salvelinus fontinalis (Mitchell) 1815 showing the male (upper) and female (lower) spawning coloration. Drawings by Mrs. Germaine A. Bernier-Boulanger in Vladykov's (1957) Album No. 1 in the Fishes of Quebec series.

I. INTRODUCTION

"The members of this genus (Salvelinus) are by far the most active and handsome of the trout, and live in the coldest, clearest, and most secluded waters. 'No higher praise can be given to a salmonid than to say, it is a charr'". (Jordan and Evermann, 1896 : 506)

A. Description and Taxonomic Position of the Speckled Trout

1. Description (Mainly after Bigelow et al., 1963)

The trunk is fusiform, its maximum thickness is about 14-16% of the standard length (SL), its maximum depth is about 19-23% of SL; the trunk depth is about 1.2-1.4 times greater than the maximum thickness, the exact relationship depending on the condition of an individual.

The dorsal profile is weakly convex, the ventral profile anterior to the anal fin is only slightly more so. The depth of the caudal peduncle is about twice its thickness. Minute cycloid scales cover the body and tail sectors; the head and fins are naked; the scales are entirely enclosed in the skin. There are about 230 along the lateral line.

The head is about 25% of SL. The snout is bluntly rounded and about 24-30% of the head length. The eyes are somewhat above the mid-line of the body and their diameter is 16-19% of the head length, but are relatively larger in fingerlings. Their posterior edges are about 24-25% of the distance from the snout to the rear edge of the operculum. The postorbital length of the head is 53-59% of the head length. The tip of the lower jaw is even with the tip of the upper jaw, or extends only slightly beyond it. The

mouth is large and moderately oblique. The maxillaries reach beyond the eyes. There are usually about 17 gill rakers on the first arch (14-21 in Newfoundland); six on the lower limb (5-9 in Newfoundland), and eleven on the upper limb (8-12 in Newfoundland). Branchiostegal rays are reported to range from 9-12 (Bigelow et al; 1963), however, no counts of branchiostegals were made on material from Newfoundland during this study.

The upper and lower jaw bones (premaxillaries, maxillaries, palatines, and dentary portion of the mandibles) each bear a single row of sharp, slightly-recurved teeth of moderate size. There is a patch of teeth on the head of the vomer, a single row of smaller teeth around the tip of the tongue, a patch of sharp, minute teeth ventrally in the pharynx and above them, two such patches side by side. There are no teeth at the base of the tongue.

The soft-rayed dorsal fin is rhomboid with angular or slightly blunted corners. Its origin is about midway from the tip of the snout to the caudal base and its longest ray is 0.9 - 1.0 times as long as the base. Dorsal rays are reported by Bigelow et al. (1963) to range from 11-14. Counts in Newfoundland range from 10-13. A small adipose dorsal fin is present with the mid-point of its base about 60% of the distance from the posterior end of the rayed dorsal fin base to the origin of the upper side of the caudal fin. The caudal fin has abruptly rounded upper and lower corners and its rear contour is slightly concave. Its breadth when spread is about twice the length of the upper and lower margins. The anal fin is rhomboid, its anterior corner is usually bluntly rounded, its posterior corner angular, and its outer margin weakly concave. Its origin is midway between the origin of the lower side of the caudal and a perpendicular from

the dorsal fin origin. Its longest ray is about as long as the longest dorsal ray. Anal rays are reported to number 9-12 (Bigelow et al. 1963), whereas Newfoundland counts ranged from 10-12. Pelvic fins have the mid-point of their base at a perpendicular about under the midpoint of the dorsal fin base. The longest ray is about as long as the longest dorsal ray. There is a conspicuous fleshy appendage at the base of the pelvics. The pectoral fins originate a little anterior to the rear edges of the operculum. The longest ray is a little shorter than the longest dorsal ray.

Bigelow et al. (1963) report the vertebral number as 58-62; however, the Newfoundland count is 56-62.

The mean number of pyloric caeca is reported by Bigelow et al. (1963) to be about 38; however no counts were made from Newfoundland in this study.

Freshwater forms have backs and upper side of some shade of olive with conspicuous vermiculations of dark olive or black. The lower part of the sides has many pale yellowish spots interspersed with a smaller number of red spots typically haloed with blue. The lower surface varies from grayish blue through shades of pale orange and a deep reddening at spawning time with a narrow white midline. The dorsal fin is a paler olive than the back, with coarse blackish vermiculations. The caudal fin is darker olive (may redden more or less at spawning time) with darker wavy crossbars, especially on the upper and lower corners. The pectorals, pelvics, and anal are some shade of pink, orange, or crimson. The pectorals and pelvics are dusty. The first ray or leading edge of the pectorals, pelvics, and anal is white or cream colored, conspicuously edged rearward with a black band. Fingerlings are more or less conspicuously marked on the sides with a series of 7-11 (av. 9) dark, vague crossbars, or parr marks.

In general, individuals taken from brightly illuminated waters and living over a pale sandy bottom are paler in color and more silvery than individuals found over a dark bottom in shady situations, but the nuptial coloration usually is more brilliant in the second case than in the first.

In contrast to the gay coloration of the freshwater form, the anadromous form, or sea trout, is more drab. The young that are destined to move out into salt water cannot, as a rule, be distinguished from those that are to remain in fresh water. In some areas, however, these future salters (as they are known in some areas) show signs of "smoltification" having turned partially silvery through the deposition of guanin crystals, although unlike salmon smolt, they still show their parr marks.

As they move out into brackish or salt water, their sides tend to become increasingly silvery and the greenish-blue-to-green marbling of their upper parts becomes obscured. Their bellies become paler, even white. Their pectoral, pelvic, and anal fins retain the white leading edge but not the black band and the other bright colors. However, the dark wavy markings on the dorsal fin and on the upper part of the caudal fin continue to be conspicuous. In extreme cases, their sides may turn as silvery as those of the Atlantic salmon, with the pale yellow spots and crimson dots showing only faintly and the marblings hardly visible.

As with the freshwater form, coloration is variable. Individuals taken side by side may show wide variation. Bigelow et al. (1963) report that none of the Newfoundland specimens examined approached the extreme sea-run coloration. Smith (1833) remarked that the most silvery of the sea trout are the ones that pass their maritime sojourn in the saltiest water and are taken

soon after they leave the stream mouths, whereas the least silvery are those that remain in the estuaries.

When the sea-run form re-enters fresh water, the back and upper sides soon darken, the silver of the sides fades, the pale spots on the sides become more orange. The pectoral, pelvic, and anal fins gradually assume the white-black-orange-to-red pattern typical of the freshwater form. The pure white of the lower sides develops into a pink-red band in breeding males and the belly tends to become gray. After a few weeks in fresh water it is impossible to distinguish sea from fresh water trout by color (Wilder 1952, Wilmot 1877).

2. Taxonomic Position

Common names: A variety of common names has been used for Salvelinus fontinalis in its range.

In Newfoundland the common names are mud trout, native trout, and simply trout. The anadromous form is known as the sea trout.

Elsewhere, popular names include brook trout, common brook trout, speckled trout, common speckled trout, eastern brook trout, eastern speckled trout, speckled char, squaretail, coaster, and char. The anadromous form is known as salter, sea trout, salmon trout, and white sea trout.

The American Fisheries Society in 1960 designated brook trout as the accepted common name for Salvelinus fontinalis.

Scientific names: There are many synonyms for this species.

(1) Salvelinus fontinalis (Mitchill) 1815 is now the accepted scientific name of the speckled or brook trout. In 1815 Mitchill brought to light existence of this species from a locality near New York City. The trivial name fontinalis means "living in springs", while salvelinus is an old

name of the char, from the same root as Salbling or Saibling.

Two color varieties of the common speckled trout are:

(2) Salvelinus agassizi, discovered by Garman in 1885 from Dublin Pond, New Hampshire.

(3) Salvelinus timagamiensis, described in 1925 by Henn and Rinkenbach from Timigami region, Ontario; known as the Aurora trout.

Although the close affinity of the anadromous form to the typical speckled trout has long been recognized, the exact systematic relationship has been, and still is, a matter of much discussion. Many of the authors considered the anadromous form as a sub-species.

(4) Salmo canadensis was probably the first name given the sea trout. It was given by Smith (1834) and appeared in Griffith's Cuvier. This name was acceptable to Morris (1864) and Gilpin (1867), both of whom published excellent descriptions of the sea trout.

(5) Salmo immaculatus was the name given by Storer (1857) who first described the sea trout. It was on the basis of a single specimen taken in 1849 in Red Bay, Labrador. Suckley (1874) and Kendall (1914) both doubt the validity of Storer's new species.

(6) Salmo hudsonicus was named by Suckley (1862) based on specimens from Hudson Bay, Labrador, and Newfoundland. He believed these fish were a new species, Hudson Bay trout.

(7) Trutta argentina or Trutta marina were named by Scott (1875) as the silver or sea trout. These were specimens taken from the St. John River, Quebec.

(8) Salvelinus fontinalis hudsonicus (Suckley) was designated as a

sub-species by Hubbs (1926), who based this on differences between Michigan freshwater and anadromous speckled trout.

Jordan and Evermann (1896), Kendall (1914), and Bigelow and Welsh (1925) all considered the sea trout and speckled trout to be identical.

A further list of synonyms and references for brackish or salt water forms are as follows:

(9) Salmo fontinalis, Mitchell, Trans. philos. Lit. N.Y., I, 1815: Perley, Rep. Fish. Bay of Fundy, 1851: Storer, J. Boston Soc. nat. Hist., 6, 1857: Garman, 19th Rep. Comm. inl. Fish. Mass. (1884), 1885.

(10) Salmo alleganiensis, Rafinesque, Ichthyol. Ohiensis, 1820.

(11) Salmo nigricans, Rafinesque, Ichthyol. Ohiensis, 1820.

(12) Salmo fario, Smith, Nat. Hist. Fish. Mass., 1833.

(13) Salmo trutta, Smith, Nat. Hist. Fish. Mass., 1833: Herbert, Frank Forester's Fish and Fish. U.S., 1850: Perley in Herbert, H. W., Frank Forester's Fish and Fish. U.S., 1850: Bell, Con. Nat. Geol; 4, 1859: Reeks, Zoologist, London, 2(6), 1870.

(14) Baione fontinalis, De Kay, Zool. N.Y., 4, 1842.

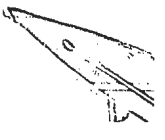
(15) Salmo symmetrica, Baird, Rep. U.S. Comm. Fish. (1872-1873), 2, 1874.

(16) Salmo agassizi, Garman, 19th Rep. Comm. inl. Fish. Mass., (1884), 1885.

(17) Salvelinus fontinalis agassizi, Jordan and Evermann, Bull. U.S. nat. Hist. Mus., 47 (1), 1896.

(18) Salvelinus (Baione) fontinalis, Vladykov, Jour. Fish. Res. Bd. Can. 11 (6), 1954.

(19) Salmo hoodi, Richardson, Ross. Voyage, App. LVIII, 1835, and Fauna Bor. Amer. III, 1836.



B. Size Range

Speckled trout are generally 14 or 15 mm. when hatched. The maximum size attained in fresh water varies with locality even within short distances. In general, the smaller trout are found in small bodies of water and the larger trout in larger bodies of water.

They are usually under 18 inches total length and 1.5 pounds in weight although specimens considerably larger have been reported (Bigelow et al., 1963).

In the smaller streams of southern Ontario, the usual weight is under a pound, but examples of 2 and 3 pounds are fairly common in the northern parts of Ontario and Quebec; and a five pound fish is considered a large one in most of the larger streams (Scott, 1954). In some northern streams and lakes, many grow to larger sizes. Goode et al. (1884), mentions one of 11 pounds from the Androscoggin River in northwestern Maine in 1860, and a Rangely Lakes fish that weighed 10 pounds after being in captivity for three years. Kendall (1914) found records of more than sixty fish heavier than 9 pounds, fifteen from 10-11 pounds, and four of 12-12.5 pounds, which had been taken in Rangely Lakes, Maine. Kendall (1914) also reported one of 11 pounds for Belgrade Lake, and one of 10 pounds from Square Lake, both in Maine. The largest trout of record weighed 14½ pounds and measured 34 inches total length. This fish was caught July, 1916, by J. W. Cook in the Nipigon River, a tributary to the north shore of Lake Superior. Hewitt (1930) took a fish of 26 inches and almost 13 pounds on the same river. Scott and Crossman (1964) suggest that these record fish were using Lake Superior in a pseudo-sea run existence.

The largest recorded fish landed from Newfoundland waters was 4 pounds 1 ounce according to Frost (1940). Kennedy (1905) referred to a

7-pound individual as Salmo fontinalis. He may have been referring to a specimen of the sea-run form; however, he had dealt with the sea-run trout separately. This author has observed a fish of almost 6 pounds as an entry in the local May 24th fishing contest held in St. John's in 1965. This trout was reported to have been taken in the Indian Bay area in Bonavista North. The author has also had numerous reports of trout of 4 pounds or over from the same area. There is some doubt that these fish were the freshwater form, as the area has numerous sea-runs and the prize fish may have been over-wintering sea trout.

Sea run speckled trout generally grow larger than those that remain in fresh water. This is particularly noticeable in situations where the freshwater growth is slow. The average weight for the New England area sea-run trout is 2-3 pounds (Smith, 1833). The average for Nova Scotia is the same (Wilder, 1952), with a record of 8 pounds (Bigelow et al, 1963).

The evidence suggests that the sea-run form may be of larger average size along the southern side of the Gulf of St. Lawrence. Goode et al. (1884) described them as usually weighing 2½ pounds, adding that they are seldom taken as heavy as 6 or 8 pounds. This agrees with Perley (1851) who reports taking 5 pounders on the north side of Prince Edward Island, and Templeman (reported by Bigelow et al, 1963) reports specimens weighing up to 8 pounds in the Bay of Chaleur.

In Newfoundland, Scott and Crossman (1964) report sea trout of 7 pounds from Alexander Bay, and trout of 8 and 9 pounds from Deer Harbour. In 1908 large trout of 10 3/4 , 12, and 15 pounds were taken in Fox River and Romaine's Brook. The largest, from Romaine's Brook, was 31½ inches long and 8½ inches deep (Morris, 1937). The large size of these fish

would indicate that these may have been sea-run brown trout (Salmo trutta). However, brown trout have never been reported from this area, and the area does produce large sea-run brook trout. Twenty-three sea-run brook trout taken from the Serpentine River included none under two pounds and one over seven pounds. Other reports include a fish of 6 pounds taken by Sir Bryan Leighton in 1904 in the Grand Codroy River. Fish of 7 or 8 pounds are reported from West Brook (north of Bonne Bay) by Palmer (1928); Millais (1905) reports thirty-three fish averaging 3.3 pounds taken off the mouth of Grandy's Brook on the southwest coast; and many of 3-3.5 pounds were taken from Newman's Sound on the east coast (Hewitt, 1930).

Millais (1905) reports sea trout taken along the Atlantic coast of Labrador "up to 7 and 10 pounds"; however these may have been Arctic char (Salvelinus alpinus). Usually, Labrador sea trout average one to four pounds. Even the largest sea-run Salvelinus fontinalis recorded weighs far less than the largest of the freshwater form from various mainland waters.

C. Natural Habits

The life span of both the anadromous and nonmigratory fish is short. The survival rate declines rapidly after they pass their fourth season, and very few survive for six years (Wilder, 1952). However Bridges and Mullan (1958) report trout of eight years, and this author's sampling has yielded an eight-year-old specimen from the Indian Bay area.

The spawning habits and early life in the streams of the sea trout do not differ much from those of the freshwater trout. As the young trout grow, they tend to move downstream from the spawning areas into deeper water and may be taken in ponds and lakes during their second and third years.

It is during their second and third years that those individuals destined to run down into salt water do so. The average size attained by the time of the first migration is about 17.5 cm. in length in Nova Scotia, and about 17.8 cm. in Newfoundland.

In Nova Scotia the seaward migration of smolts begins in April and May. In the Little Codroy River on the West coast of Newfoundland, the chief run begins in late April or early May and continues until mid-June (Murray, as reported by Bigelow et al., 1963). Weed (1934) reports this is preceded by some downward movement as early as January and February. Blair (as reported by Bigelow et al., 1963) states that they descend around the middle of May in southern Labrador, and not until June in northern Labrador.

The movements of the sea trout after they have gone into the sea varies widely from locality to locality. Generally, though, the majority probably remain within the influence of the river during the entire duration of their time away from fresh water. However, sea trout have been taken a mile or so off shore. The availability of food, rather than salinity, is probably the determining factor.

White (1942) reports that while in the sea off Nova Scotia they are in schools in water five to ten feet deep around inner islands and wharves. Fish of the same size tend to school together. This is supported by Bigelow and Welsh (1925) for Gulf of Maine sea trout.

They may even return temporarily to the stream mouth in search of food. Templeman (as reported by Bigelow et al., 1963) reports sea trout re-entering Fox Island River in June and July, apparently to feed on smelt there, and then returning to the sea.

The greatest recorded distance travelled is about 8 miles as reported by Doan (1948) for sea trout off the Nelson River, Hudson Bay; by White (1942) for trout marked on the Moser River; and by Mullan (1958) for trout marked along the south shore of Cape Cod.

The length of the sojourn varies widely, averaging about two months (White, 1941). During this time in the sea they feed heavily and grow relatively rapidly. However, after re-entering fresh water, they cease feeding, perhaps because of the scarcity of prey of the size to which they have become accustomed.

Backus (1957) reports that there is probably a third "form" of speckled trout. This is the estuarine form which is found mainly in the estuaries and brackish water of river mouths and which follows the tides in and out of the lower reaches of the rivers. In Labrador these trout are termed "slob".

Generally the migratory trout spawn in the autumn of the same year in which they make their first seaward migration.

The upward migration takes place from late May through June on Cape Cod with a few entering in September, and perhaps even as late as November (Mullan, 1958). On the east coast of Maine, the main run is from May until early August. In Nova Scotia the chief run is from mid-June to August (White, 1940). Breck (1909) reports the heaviest run in Cape Breton during July as in Newfoundland. In southern Labrador, Blair reports they are running up stream in September.

The sea trout usually spend the summer in the deep shaded and cool pools of the river, but some individuals proceed immediately up the river as is evidenced by a report of sea trout taken from Oliver's Brook (a tributary

to Gambo Lake) late in July, at least ten miles from the sea (Scott and Crossman, 1954).

The spawning habits of both sea trout and nonmigratory trout do not differ greatly except for the sea trout's ascent from the sea. Both forms spawn exclusively in fresh water in autumn at reported temperatures ranging from 9.4°C to 4.4°C. (Bigelow et al., 1963). Frost (1940) gave the water temperatures at spawning in Murray's Pond (near St. John's) as 9.0°C to 3.5°C. Spawning generally takes place earlier in the season in the northern part of the range. The time varies with the degree of cooling of the water and to some extent with the flow.

Brook trout probably spawn from mid-October until early December on Cape Cod; from mid-October into December in New Hampshire (Goode, 1884); from mid-October into November in Maine (Kendall, 1914); from late October through December into January on Prince Edward Island (White, 1934); during October in the Moser River, Nova Scotia (White, 1940); and from mid-October to middle or late November on the east coast of Newfoundland at Murray's Pond. Frost (1940) gave specific dates as October 15 to November 18. In shallow exposed streams where the water cools rapidly, spawning may occur as early as late September (White, 1934). Vladykov (1956) recorded spawning as early as late August for some high-lying Laurentian Lakes in Quebec. Ricker (1932) gives the spawning date in southern Ontario as mid-October to mid-December. No information is available on the spawning time in Labrador; however, Dunbar and Hildebrand (1952) say that it is probable that speckled trout in Ungava Bay spawn from September to October.

The speckled trout spawns on bottoms of sand or gravel in streams, or if none are available, in suitable lakes or ponds, where currents or

inflow from springs keep the eggs clear of detritus.

In spawning runs the males appear first and exhibit a definite territorial behaviour. The females dig the redds into which the eggs are shed and are fertilized by the attendant males. The pairs now move upstream, and the females cover the redds. Spawning may occur as frequently as every few minutes or as infrequently as every half hour or so. The eggs vary in color from yellow to orange, and in size, averaging about 5 mm. in diameter. The eggs hatch the following March, April or May, depending on the water temperature. The upper thermal limit for their development is 11.7°C, and eggs usually develop in water as cold as 1.7°C (Embody, 1934). The alevins, about 14 or 15 mm. long at hatching, carry a large yolk sac at first and remain in the gravel of the redd until the yolk sac is absorbed. At about 38-50 mm. in length they leave the redd and swim into mid-water.

The spawners recover quickly and in a couple of months, if food is available, the fish will again be in excellent condition (Frost, 1940).

D. Distribution

The general range is eastern and north-central North America, cold waters from northernmost Labrador, the southern part of Hudson Bay, and the tributaries of James Bay, southward along the coast to northern New Jersey, from there inland along the Allegheny Mountains to North Carolina and northern Georgia, westward to the western slope of the Alleghenies in the southern part of its range. The northern part of its range is to northwestern Iowa, Wisconsin, southeastern Minnesota, Lake Superior with its northern tributaries and to eastern Saskatchewan. It is also widely and successfully introduced in the high altitude streams and lakes in the Rocky Mountains of the United States, and in California, British Columbia, and southern Alaska.

It has been successfully introduced in various localities in South America and South Africa. Jenkins (1954) reports that the speckled trout was introduced to the European continent in 1889 and tried in some British streams. He reports that the speckled trout invariably disappears from British streams, but has become established on the Continent.

Many migratory populations formerly existed along the New England coast but have disappeared. Herbert (1849) describes migratory populations as far southward as Long Island, New York, as does Goode (1884). Smith (1833) reported that they abounded along the southern shores of Cape Cod in southern Massachusetts. They have now all but disappeared on Long Island, and only a few have been reported off Cape Cod.

They have never been reported between Cape Cod and Cape Elizabeth, Maine. However, Evermann (1905) reports them from small tributaries of Casco Bay, Maine, and Bigelow et al. (1963) report sea-going populations in the area near Jonesport, Maine. Huntsman (1922) found no evidence of them along the New Brunswick shore of the Bay of Fundy, but White (1941) reports them at the head of the bay on the Nova Scotia shore.

Information concerning populations along the outer Nova Scotian coast west of Halifax is scanty. However, east of Halifax they are found all around Cape Breton, along the entire southern coastland of the Gulf of St. Lawrence, around Prince Edward Island, the Magdalens, and the Island of Anticosti. Palmer (1928) reports sea trout in 26 rivers along the west coast of Newfoundland, in about 39 along the south coast, and in about 25 along the east coast.

Blair (as reported by Bigelow et al., 1963) reports populations along the north shore of the inner part of the Gulf of St. Lawrence. Barteau

(1905) reports them from Blanc Sablon Bay, Barge Bay, Wreck Bay, Red Bay, Chateau Bay, and Temple Bay within the Straits of Belle Isle. Barteau reports them northward in St. Lewis and Capelin Bay, and also in Hawke Bay. Backus (1957) reports large runs of Salvelinus fontinalis in the Hamilton Inlet-Sandwich Bay region. Weed (1934) reports them northward at Main. Nutak Harbour (57° 28' N) is the northernmost area reported as supporting sea-run speckled trout. However, Gordon and Backus (1957) think it is probable that small populations are continuously distributed around Cape Chidley and into Ungava Bay. Dunbar and Hildebrand (1952) report sea-going populations in rivers draining the southern part of Ungava Bay. Vladykov (1933) reports them in the southern part of Hudson Bay, especially around the shores of James Bay.

E. Status of the Speckled Trout of Insular Newfoundland

Insular Newfoundland is situated between the 46th and 52nd parallels of north latitude, and between 52° and 60° west longitude. It is bounded by the Gulf of St. Lawrence on its west coast, while the Northwest Atlantic washes the north, south, and east coasts. It has an approximate surface area of 42,734 square miles, with fresh waters (lakes, ponds, rivers, and streams) occupying one quarter of the surface.

The province's freshwater piscine fauna is sparse due to past glaciation and geographic location. The only game fishes present are those of the family Salmonidae. These include the anadromous and landlocked Atlantic salmon, (Salmo salar); the anadromous and landlocked arctic char, (Salvelinus alpinus); the two exotic salmonids, the brown trout (Salmo trutta), and the rainbow trout (Salmo gairdneri). The exotics are represented mainly on the Avalon Peninsula. The lake whitefish, (Coregonus clupeaformis), sometimes

classed as a game fish, is restricted to two adjoining ponds in the St. John's area.

Finally, there is the speckled trout in its anadromous and freshwater forms.

The speckled trout is so widespread in this province that no attempt to describe its distribution is required. As Scott and Crossman (1964) stated, "The often used term of generally distributed is nowhere so accurately applied to any fish as it is to the brook trout in Newfoundland. . . to attempt to detail its distribution would be a folly." It will suffice to say that hardly a lake, pond, river, or stream in the Province is without it. Since this species is so widely distributed and easily accessible, it bears the brunt of the Province's angling pressure. It is somewhat unusual then, that a species so widespread and so important should have had as little investigation in Newfoundland when compared with the voluminous literature on the species from other areas in its range.

The first investigation of the speckled trout in Newfoundland was carried out in 1936-38 by Frost. This was a cursory study involving observations on spawning habits, food, parasites, growth rate, and some limnological studies of the ponds concerned. The study was limited to the Avalon Peninsula, with actual observations only at Murray's and Butler's Ponds, near St. John's, and Bay Bulls Long Pond. Creel censuses and verbal information was obtained from other areas on the Avalon. Since Frost's report in 1940, no specific investigations on the speckled trout in Newfoundland waters have been undertaken.

Although the importance of the speckled trout is generally underestimated, one should not lose sight of the fact that it is the most exploited

of our freshwater game fishes and its value as a resource is large. It is the aim of this study to add to the scanty information on the species in this area.

Because little work of even a general nature has been attempted on this species in this Province, this study sets out to examine some of the broader aspects of the speckled trout's biology.

In general, the study may be divided into two broad categories:

Firstly, because the speckled trout is so widespread and has formed what would appear to be many localized populations, one of the aims of this study is to determine if indeed population differences do exist due to geographic separation, and if so, to what extent. This aspect deals mainly with a consideration of meristics.

The second broad aim is an examination of the species in all of its natural habitats. Because the freshwater piscine fauna is sparse in this Province, the speckled trout is widely distributed in varying sizes and types of bodies of water. This aspect is concerned mainly with a consideration of age and growth.

Also considered are some aspects of its life history and ecology such as reproduction, parasites, and food.

II. Sampling Methods and Materials

This study not only attempts to examine the speckled trout on the basis of its geographic separation, but also attempts a comparative examination of the species in all of its possible natural habitats; for this reason, sampling was carried out in streams, rivers, ponds, and lakes.

Unfortunately, in a broad survey of this type where time was an ever present factor, no limnological studies as such were made of the sampling areas. The only attempt made in this direction was a rough mapping of the sampling area showing sampling stations, and the calculation of surface area. Maps of the sampling areas, taken from the Canadian Mines and Technical Surveys Topographical Series, were projected onto a squared-paper screen, and the surface areas calculated.

The collection of data for this study was carried out during the summers of 1965 and 1966. Sampling areas are shown in Figure II. 1.

The samples collected in the summer of 1965 included three from areas on the Avalon Peninsula and a fourth sample was collected in the Indian Bay area of Bonavista North. The three Avalon Peninsula samples were each a combination of gill netting and angling, while the Indian Bay sample was taken by gill netting alone.

For the Avalon Peninsula samples, a gang of nylon gill nets composed of four nets with stretched mesh size 1½", 2", 2½", and 3 inches were allowed to fish overnight. Each net measured 50 yards in length and was six feet in depth, and the gang was invariably set with the 1½ inch net tied to

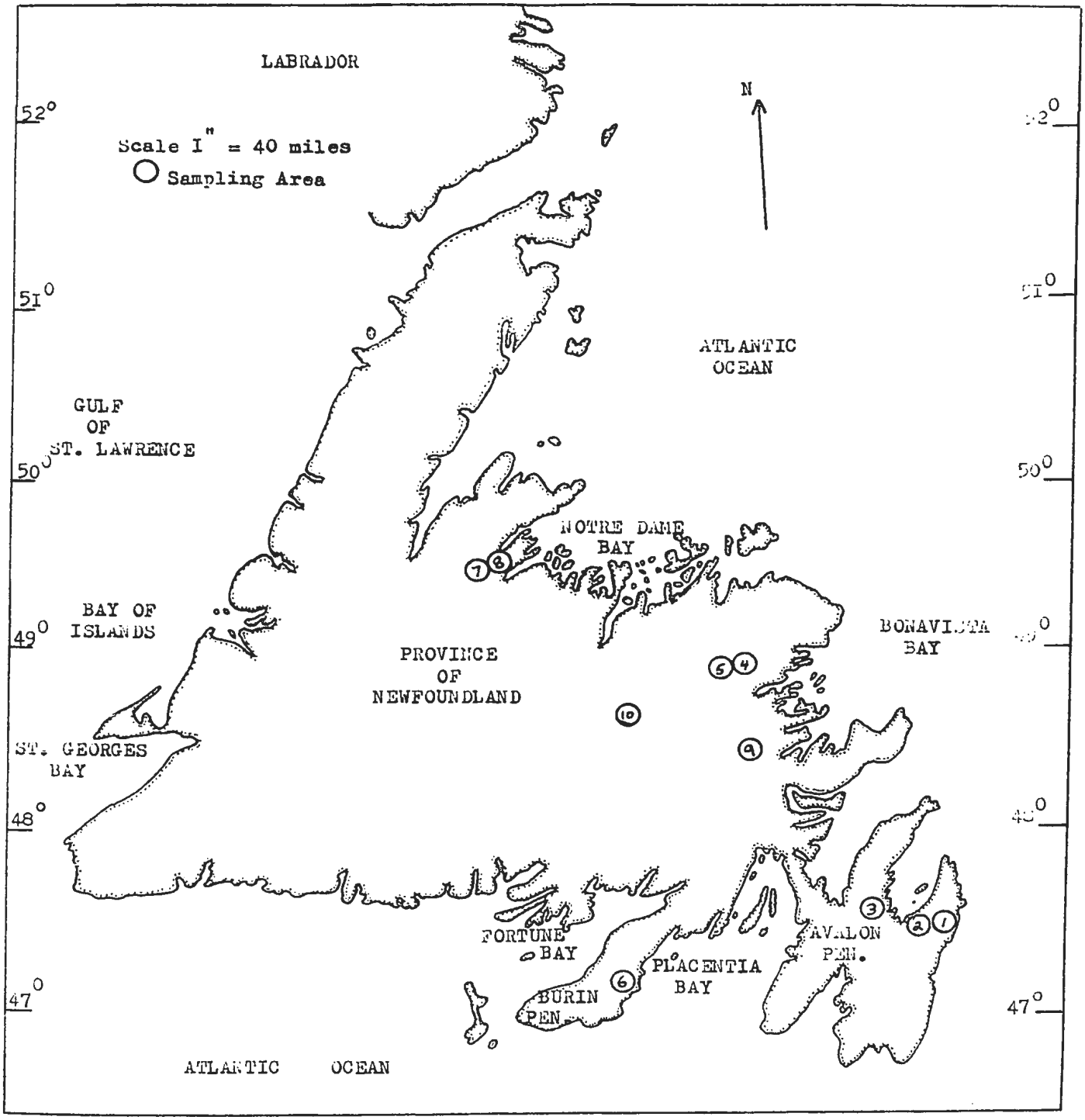


FIGURE II. 1 Map of the Province of Newfoundland showing the various localities sampled.

the shore and the mesh size increased as the net ran out into the water. The gill netting was supplemented by angling, using both artificial fly and spinning lures.

The Indian Bay sample was taken by gill netting only. The nets consisted of one of 1½ inch stretched mesh, and the other of 2½ inch stretched mesh. These were the only mesh sizes available as another research project required the use of the other nets. No angling was carried out.

Specifically, the Avalon Peninsula samples consisted of (1) a sample from Thomas' Pond (about 10 miles outside St. John's along the Trans-Canada Highway) taken from June 2nd to June 12th, and consisting of 105 specimens; (2) a sample from Angle Pond (Mahers) taken from June 17th to June 30th, and consisting of 110 specimens; and (3) a sample from Stephens' Pond (near Bay Bulls) taken throughout the summer months (June to September), and consisting of 104 specimens.

The Indian Bay sample was taken from Big Bear Cave Pond about 5 miles in the Bowater's woods road from the main Bonavista North road. The sample was taken from August 13th to 16th, and yielded 122 specimens.

Beginning in the spring of 1966, the survey was expanded and other areas were sampled.

A return to the Indian Bay area, specifically to Indian Bay Big Pond, yielded a sample of 100 specimens taken from June 24th to 25th.

In August two final areas were sampled. The first of these was at Burin Bay Arm, where from August 10th to 12th a sample of 85 fish was collected at Berry Hill Pond. The second sample consisted of 115 fish taken at Indian River, in the Notre Dame Bay area. The sample was composed of 20 sea-run specimens taken August 17th at the Canadian Department of Fisheries controlled

flow Atlantic salmon spawning channel, and the remaining 95 stream-resident fish were taken on August 16th in a small tributary of Indian River, Twenty-three Mile Brook.

Sampling of the Burin Bay Arm area and a return to the Indian Bay area was a combination of gill netting and angling (fly and lure); the gang of nets used had the same mesh sizes as the one used the previous year.

The collection of a sample of stream-resident fish from Twenty-three Mile Brook was made by hand seining and angling, while the sea-run trout were taken by seine at the spawning channel. See Figures II. 2-9 for sampling areas and stations.

Best catches were invariably taken in shallow water near the shoreline, and both the 1½ inch and 3 inch mesh appear to be more selective than the other two mesh sizes; this will be discussed further when sources of error are considered.

Further smaller samples were taken in late autumn of 1966 by gill netting and angling for the purposes of reproduction and fecundity studies. These included fish from Murray's Pond (near St. John's), Bay Bulls Long Pond, and Donney's Pond on the Witless Bay Line. Also included in fecundity studies were fish from Murray's and Butler's Ponds and Peter's River (St. Mary's Bay) which were taken in 1962 and 1961 respectively, and preserved in 10% formalin.

Also included in sampling were 70 specimens obtained from the Newfoundland Game Fish Protection Society trout hatchery at Murray's Pond. This sample was the result of heat death at the hatchery during a particularly hot day with low water level in August, 1965, these fish having been imported from Nova Scotia earlier in the year. These fish were used for meristic study.

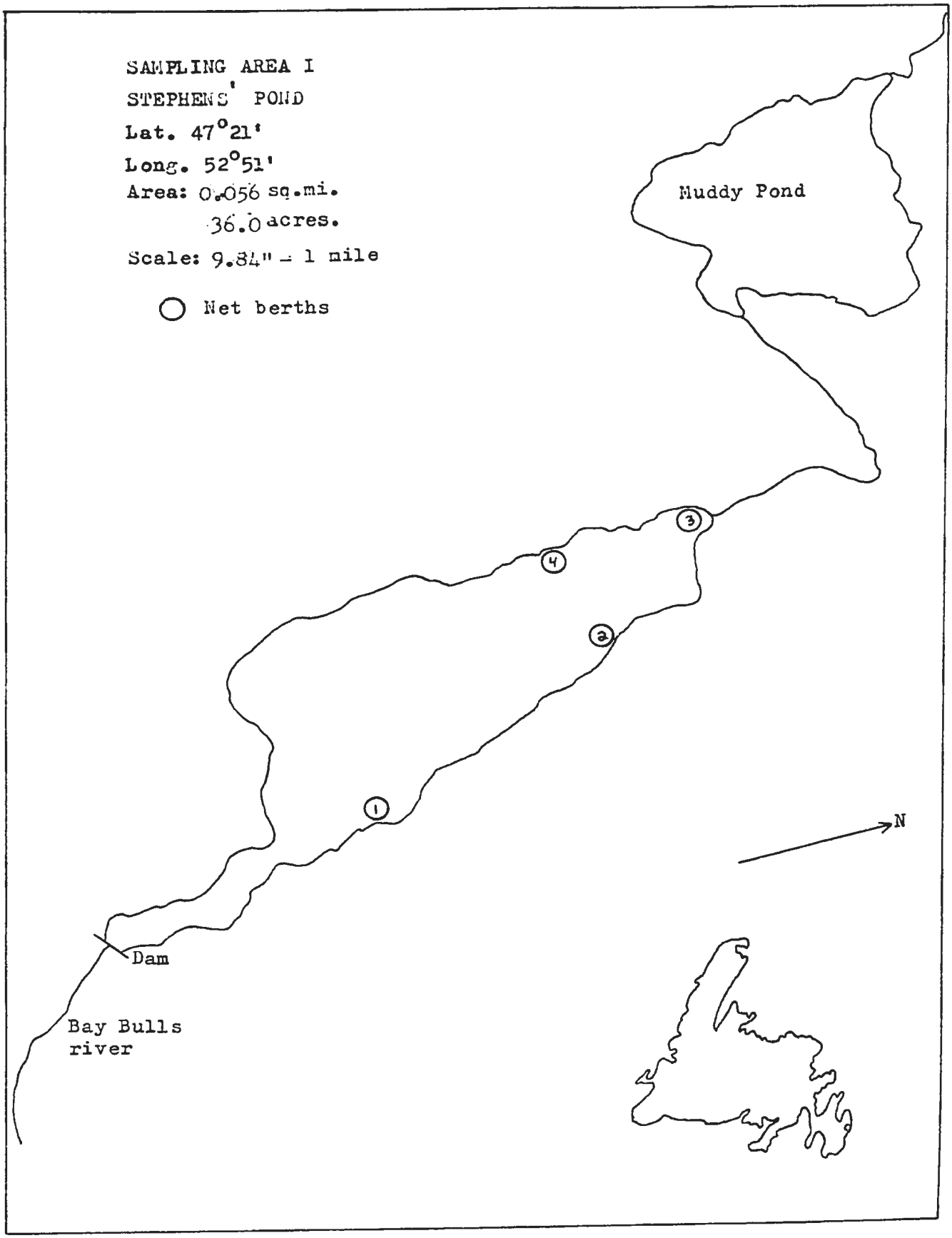


FIGURE II. 2. Map of Stephen's Pond showing sampling stations (net berths).

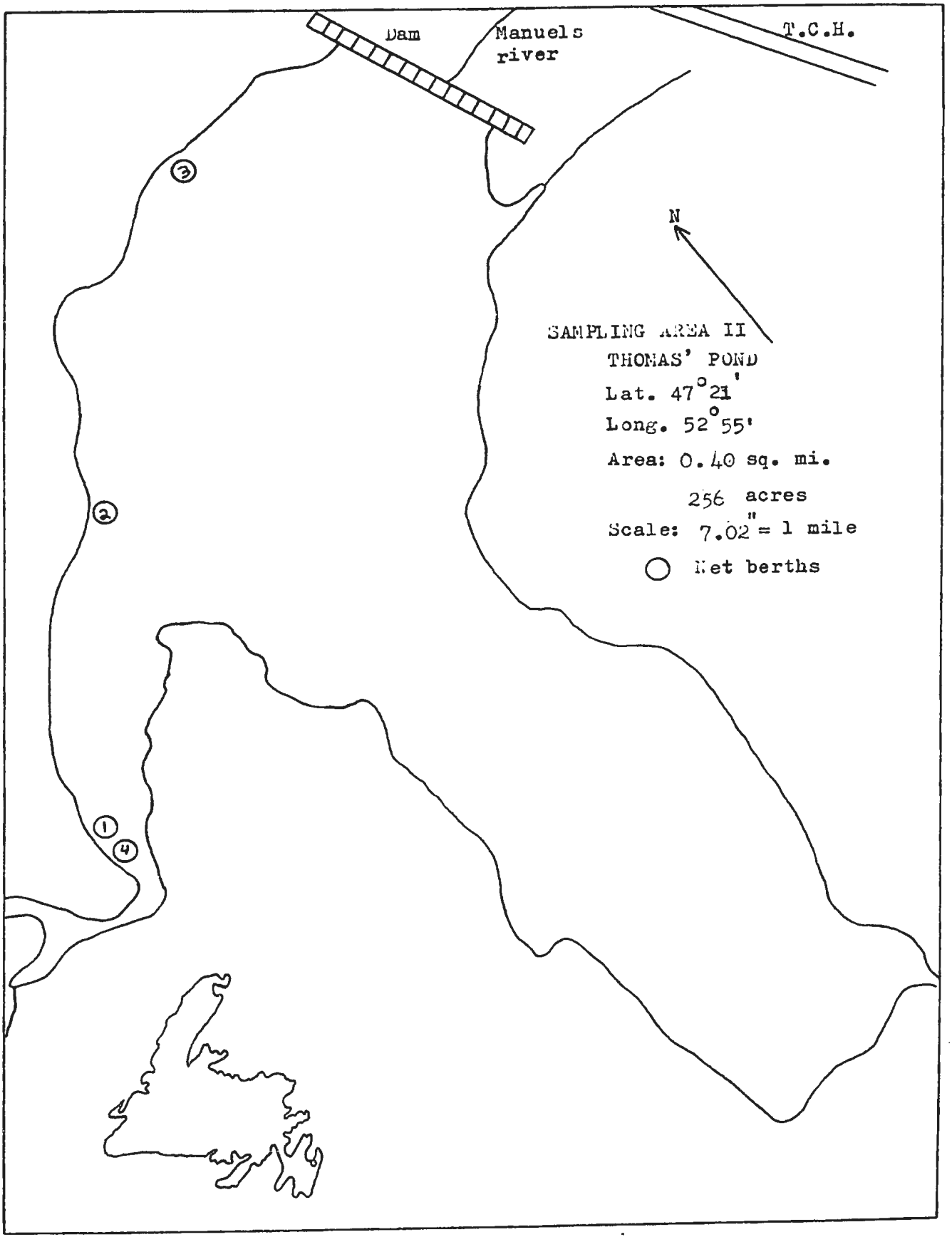


FIGURE II. 3. Map of Thomas' Pond showing sampling stations (net berths).

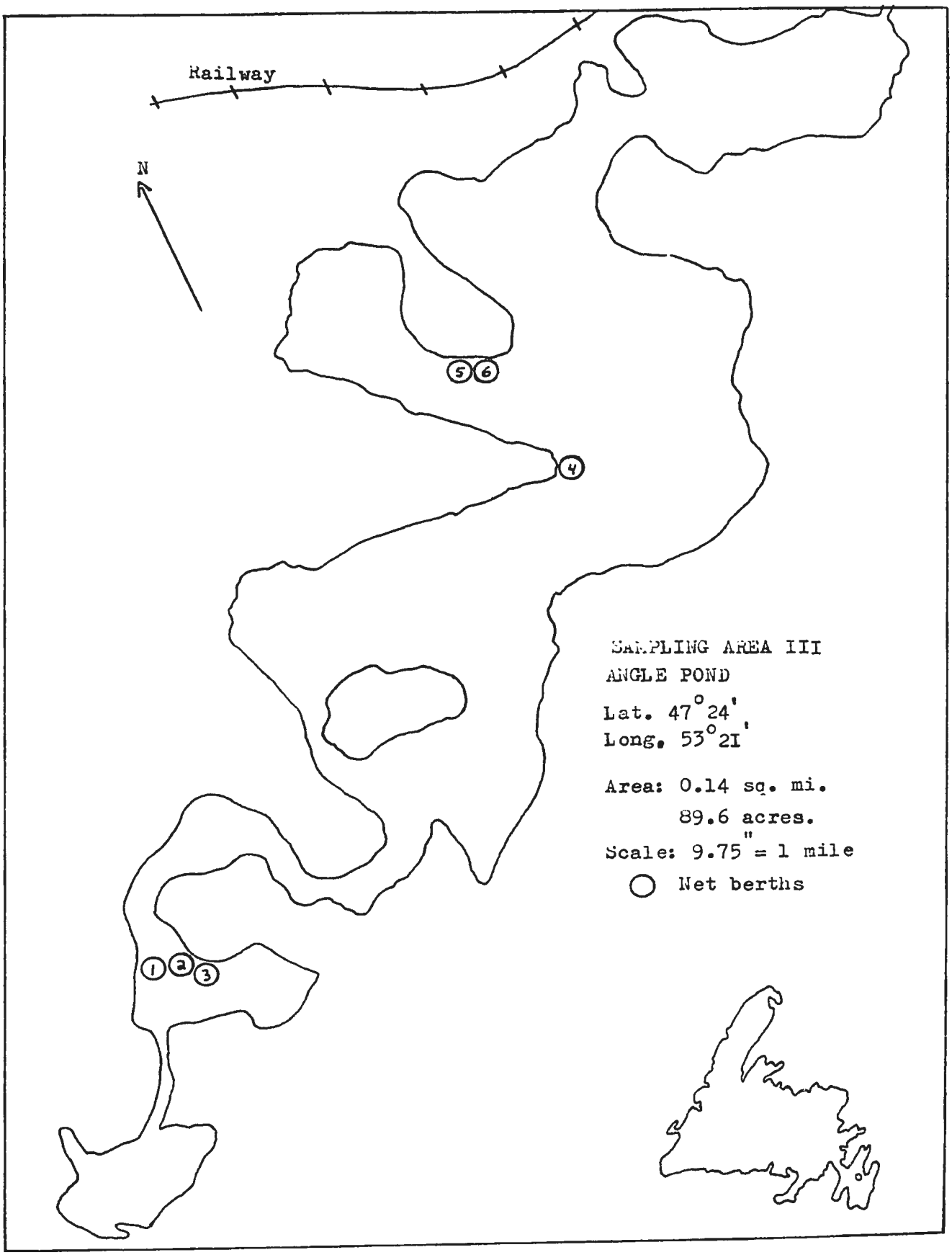


FIGURE II. 4. Map of Angle Pond showing sampling stations (net berths).

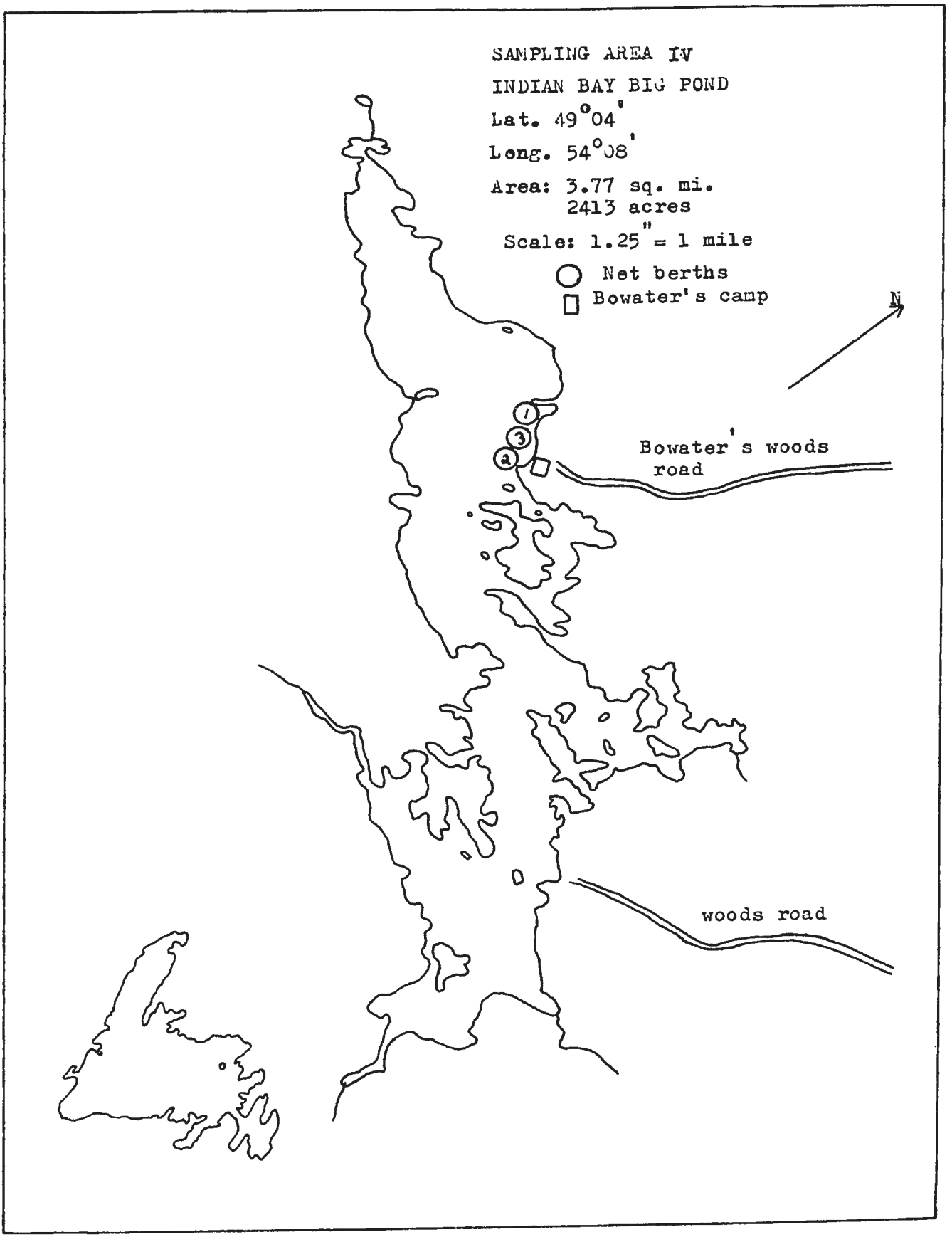


FIGURE II. 5. Map of Indian Bay Big Pond showing sampling stations (net berths).

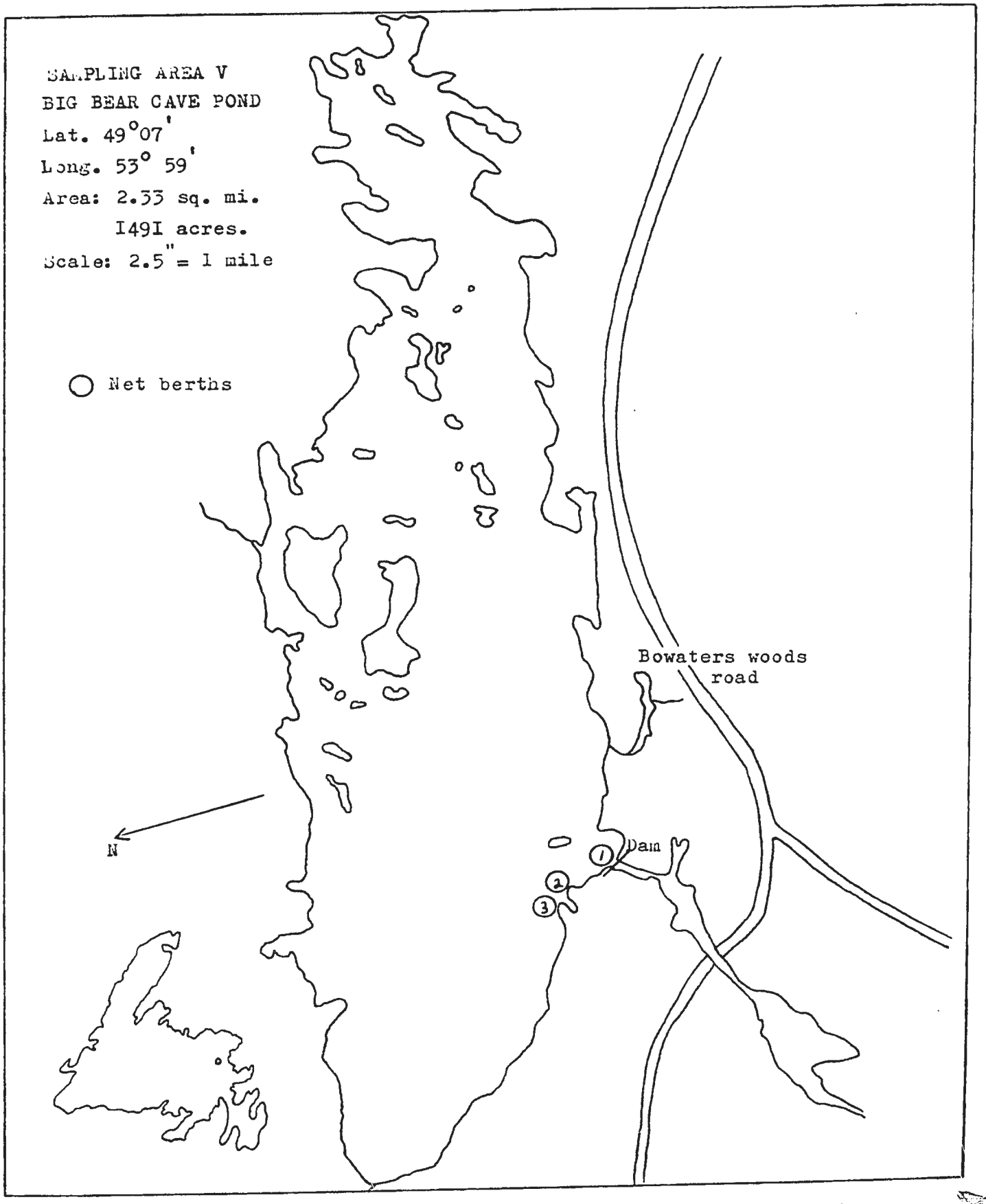


FIGURE II. 6. Map of Big Bear Cave Pond showing sampling stations (net berths).

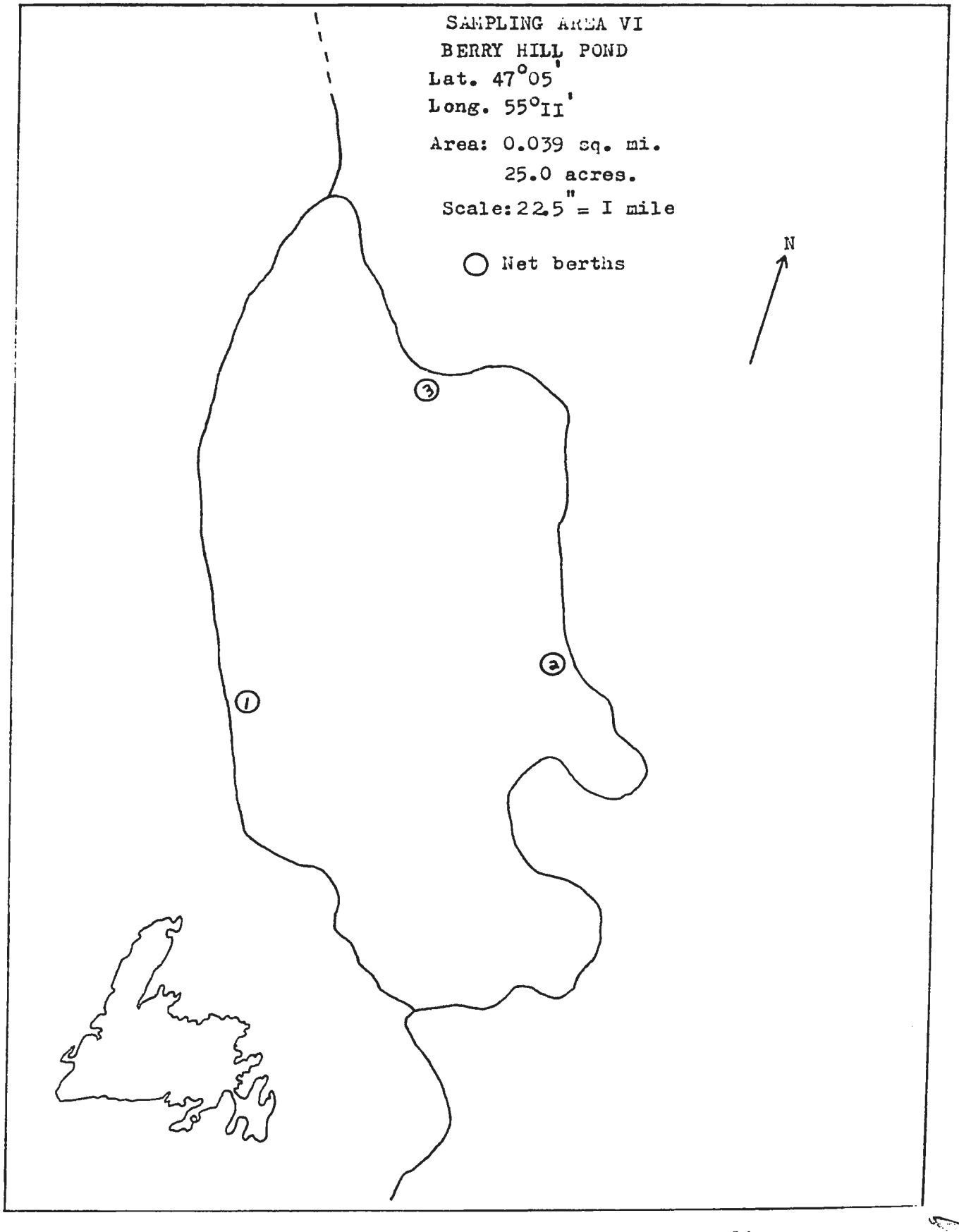


FIGURE II. 7. Map of Berry Hill Pond showing sampling stations (net berths).

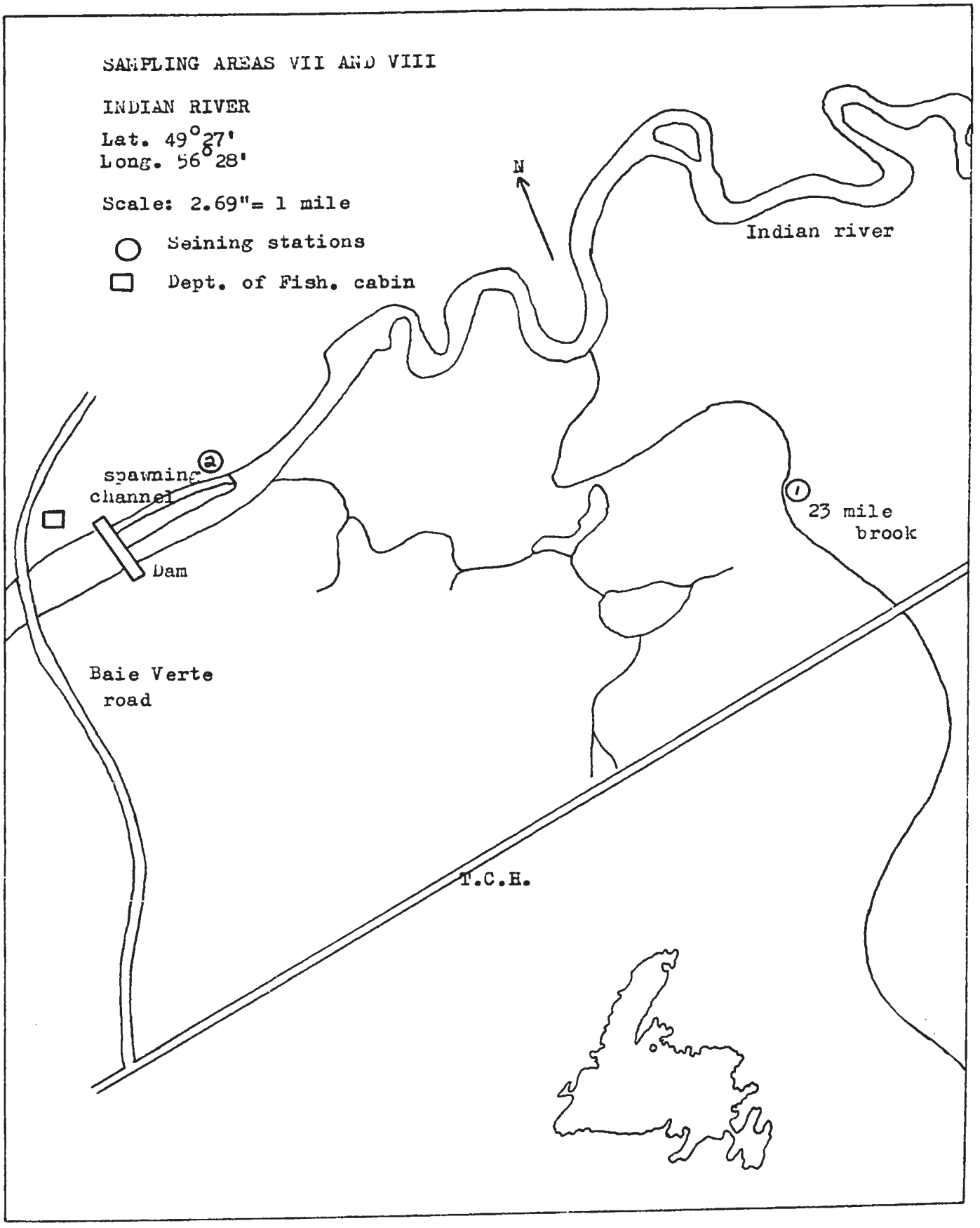


FIGURE II. 8. Map of Indian River showing sampling stations.

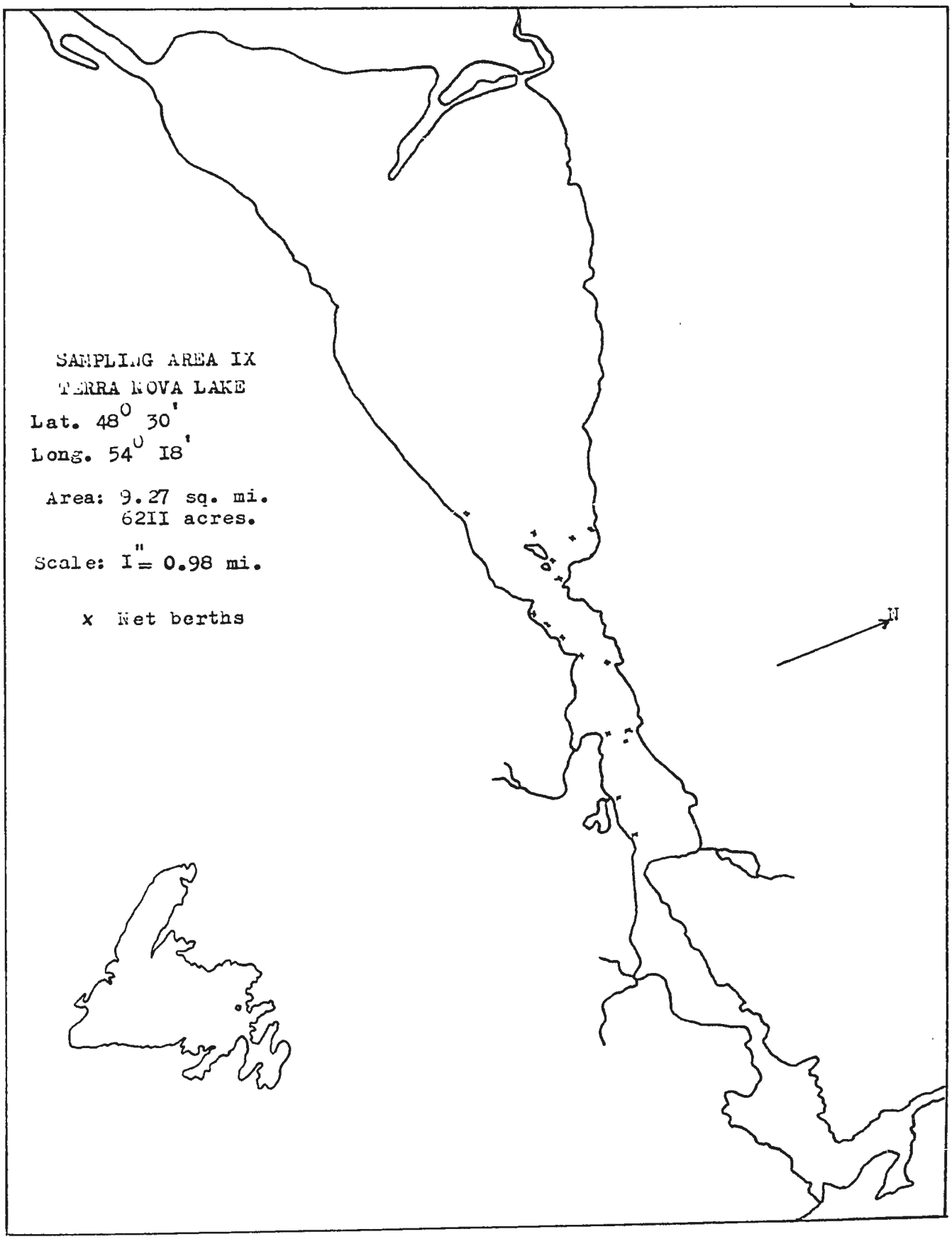


FIGURE II. 9. Map of Terra Nova Lake showing sampling stations (net berths).

Besides the above mentioned samples, through the kind assistance of Dr. C. W. Andrews, further data were obtained. These included sampling data from the Southwest branch of the Upper Gander River, and from Terra Nova Lake.

Finally, statistics were obtained from several sporting goods firms on 25 prize trout during the annual May 24th fishing contest held in St. John's in 1965. These fish had been taken in the Indian Bay area.

Source of error: Gill nets are passive fishing gear; therefore, their catch depends upon the movement of the fish themselves. Therefore, the more active individuals in a population have a greater probability of being meshed. Other factors which influence the catchability of fish in gill nets are: (1) the occurrence of spines, projections, etc., which increase the probability of meshing, (2) the mesh size, (3) season of the year and even time of day, (4) the fish population is usually in a nonrandom distribution, (5) elastic stretching of the net, (6) visibility of the net, and (7) the shape of the fish, including compressibility of its body. (Clark, 1960; Moyle, Kuehn and Burrows, 1948; Houser and Ghent, 1964.)

As was previously mentioned, the greatest catches were obtained in shallow water near the shore in the smaller mesh sizes; very few fish were taken at great depths in the larger mesh sizes. However, those fish taken at greater depths and in larger mesh sizes were usually the largest fish of the sample. This may be explained as follows: (1) The number of large trout in any population is small, and the larger mesh size is selective for them, while smaller fish, if in the area, would not mesh. (2) The fish tend to be more abundant in the shallower waters of the ponds.

The fact that the 1½ and 3 inch mesh seemed to be more selective than the other mesh sizes was indicated by sampling in Big Bear Cave Pond in 1965 when only these two mesh sizes were used. As a result, sampling yielded a bimodal length distribution (Figure III. 1) with the first modal group representing smaller fish taken in the 1½ inch mesh and the other modal group being taken in the 3 inch mesh.

One answer to the selectivity problem is the use of experimental gill nets; here the various mesh sizes are represented by equal lengths of netting arranged by mesh size in a graduated order. Because a variety of mesh sizes are incorporated, a potential for taking a truly representative sample does exist. However, the extreme mesh sizes are often fished at different depths, and probably at different ecological situations. Houser and Ghent (1964) therefore designed an experimental gill net based on the latin square with the hope of cutting down the sampling error.

When we consider that both the size and nature of the error in which gill nets catch fish is often unknown, and that selectivity is poorly understood, it is apparent that gill net catches can only be considered as measures of population size, and distribution in a very general sense. Gill netting can be of a general quantitative value however when used comparatively and in conjunction with some other sampling technique, but the limitations should not be overlooked.

The use of angling as a sampling technique has also come in for some criticism. Cooper (1953) and Rupp (1955) both suggest that angling captures only the faster growing and hence larger members of each age group, and that data collected in this way refer only to that portion of the population available to anglers.

The collected fish were frozen as quickly as possible, and all measurements were recorded immediately following thawing, so that all measurements are as close to values of the fresh condition as possible.

All measurements were made in the metric system. The following was recorded for each fish:

(1) Length: The fork length, measured from the anteriormost extremity to the notch in the caudal fin, was recorded to the nearest tenth of a centimeter.

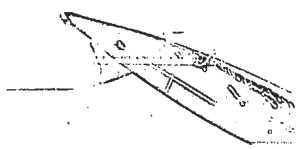
(2) Weight: Both whole and gutted weights were recorded to the nearest tenth of a gram using a spring balance.

(3) Sex and Maturity: The gonads were observed macroscopically and the sex determined. The stage of maturity of females was recorded and was based on the scale used by Vladykov (1956). Ovaries which were to be used in fecundity studies were removed and stored in appropriately labeled vials in 10% formalin.

(4) Food: The entire stomach from the lower esophagus to the pyloric sphincter was removed and again placed in vials with 10% formalin. The contents were examined at a later date.

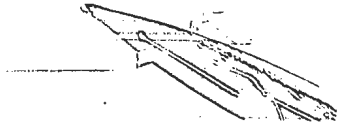
(5) Parasites: The only parasites considered were the internal and external macroscopic variety; both type, location, and degree of infestation were recorded.

(6) Meristic characters: The meristic characters used were gill rakers, vertebrae, dorsal and anal fin rays. Gill rakers were invariably removed from the first arch on the left side, except in cases where both right and left arches were compared. Fin rays were collected by clipping the fins and placing them with the gill rakers in appropriately labeled vials in 10% formalin, to be examined at a later date. Vertebral columns were obtained



from filleted and boiled fish, except in one instance where the fish were x-rayed.

(7) Age Determination: Both scales and otoliths were used in age determination. The largest otolith, the sagitta, was removed from each side by making a deep transverse out behind the operculum, and a deep longitudinal out mid-dorsally along the skull. Scale samples were removed from just posterior to the dorsal fin and above the laternal line. Both scales and otoliths were placed on scale paper and stored in scale envelopes.



III. Size Composition

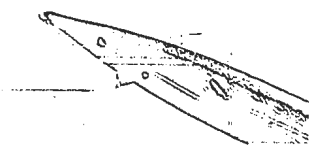
The statistics used were calculated after Hoel (1965).

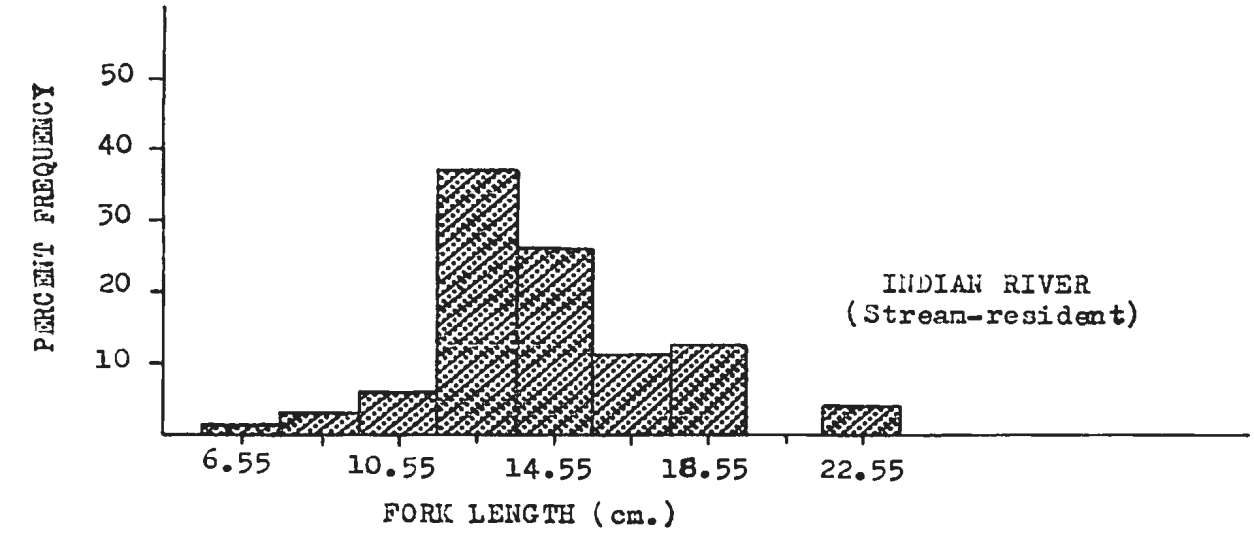
A. Length

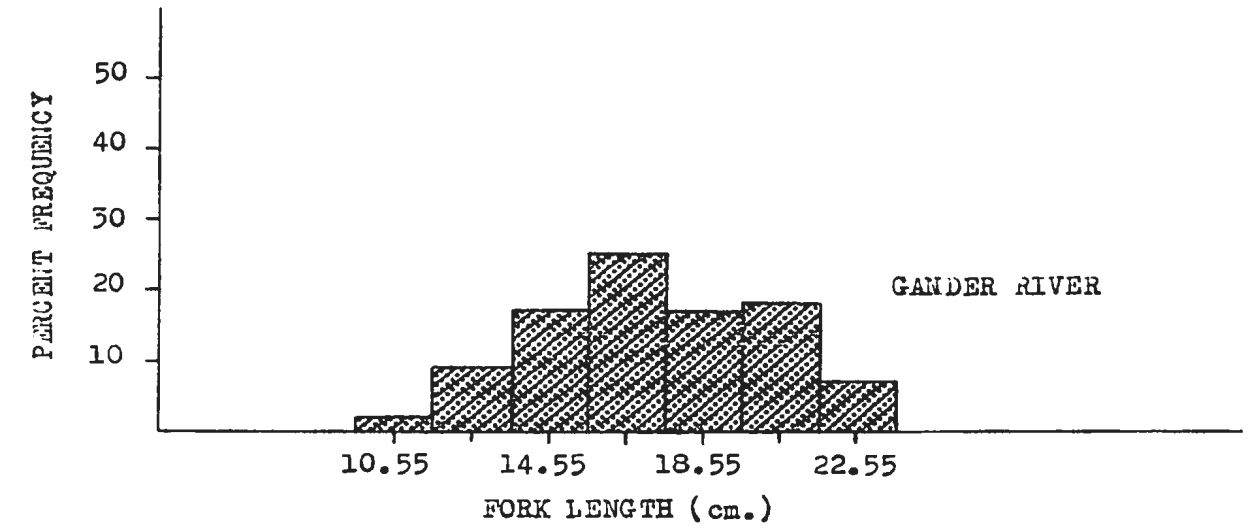
Fork length distributions are shown in Table 1 Appendix I, where the fish are grouped into 2.0 cm. length classes. The length distributions are presented in histogram form in Figures III. 1 (a-d).

In general, the distributions are unimodal and skewed to the right (positive skewness). However, both Big Bear Cave Pond and Terra Nova Lake show bimodal distributions. This is thought to be the result of sampling error in both instances. In Big Bear Cave Pond, modes appear at both 16.55 cm. and 26.55 cm., and this is blamed on the selectivity of the gill net mesh as was previously discussed in sampling errors. Terra Nova Lake shows two modes; one at 22.55 cm. and the other at 26.55 cm. Poor sampling of the 24.55 cm. length class is blamed, and if this class had been stronger, the bimodality would be removed. In neither instance is year class dominance suggested to be the reason.

Generally, as the size of the body of water increases, the length distribution shifts to the right, and the degree of skewness increases, indicating both an increase in mean length, modal length, and range. This is in agreement with Ricker (1932) and Scott and Crossman (1964), who suggest that the maximum size attainable is correlated indirectly with the size of the body of water, and directly with the presence of larger food organisms in the larger bodies of water. This can be seen quite clearly when the mean







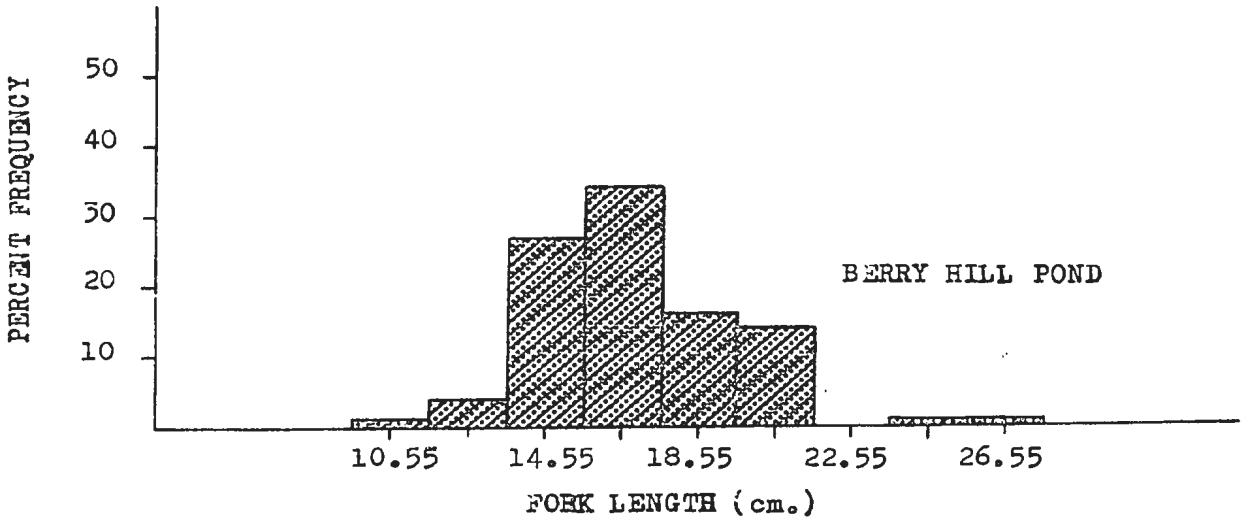


FIGURE III. 1 a. Fork length distribution of Indian River, Gander River, and Berry Hill Pond speckled trout.

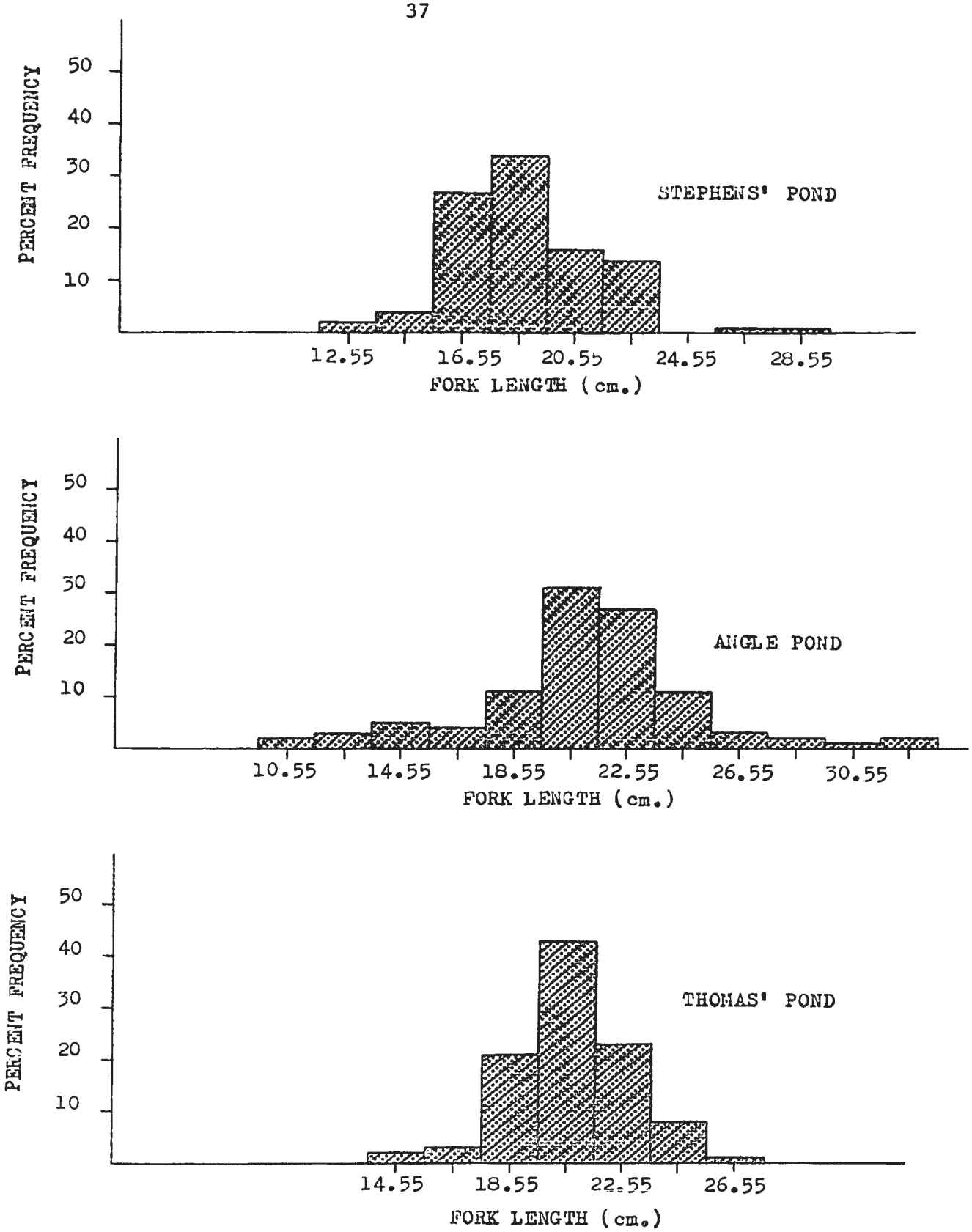
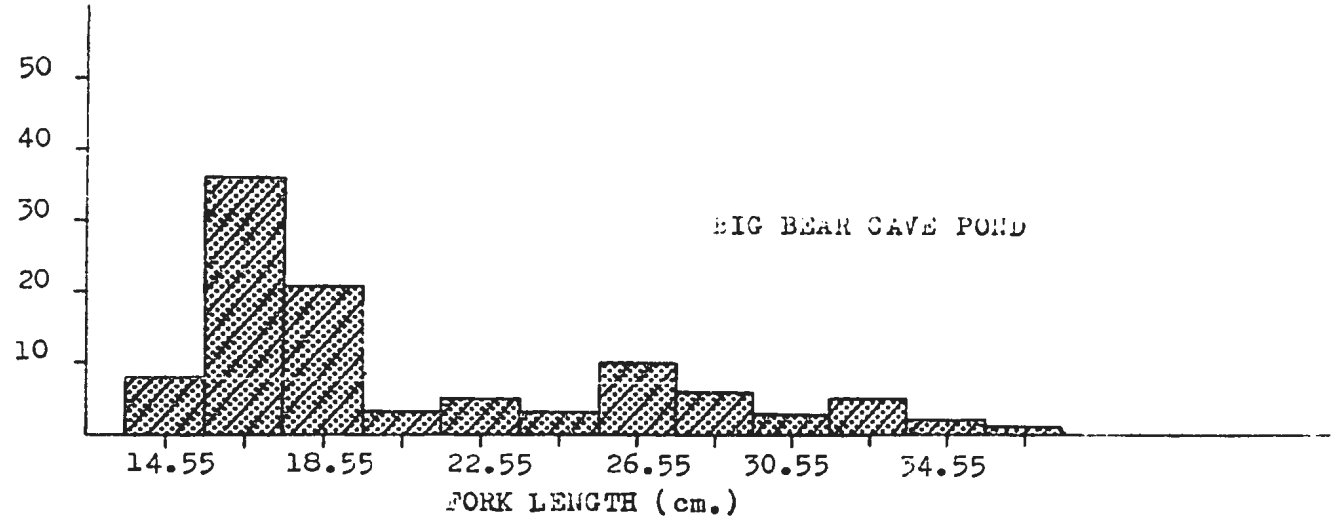
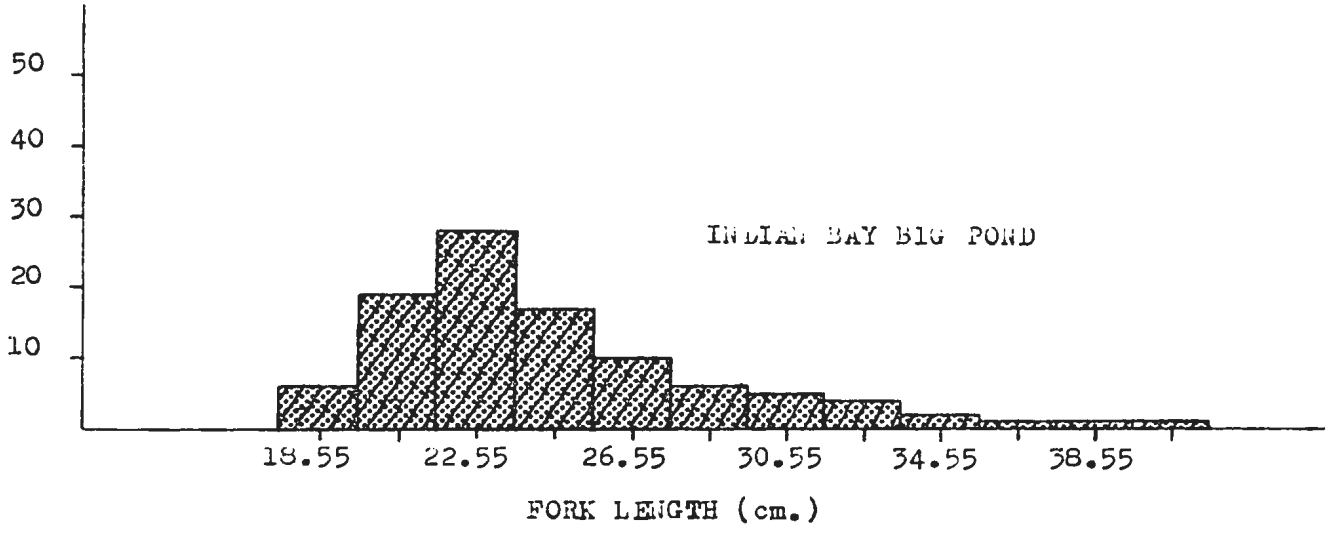
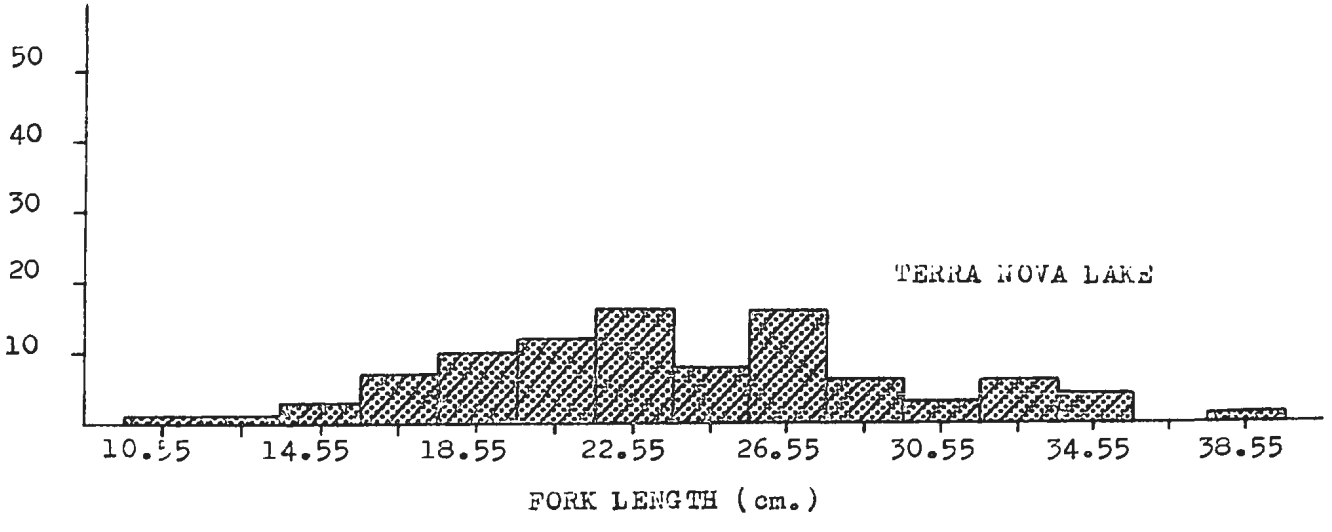


FIGURE III. 1b. Fork length distribution of Stephen's Pond, Angle Pond, and Thomas' Pond speckled trout.

FIGURE III. 1 c. Fork length distribution of Big Bear Cave Pond, Indian Bay Big Pond, and Terra Nova Lake speckled trout.







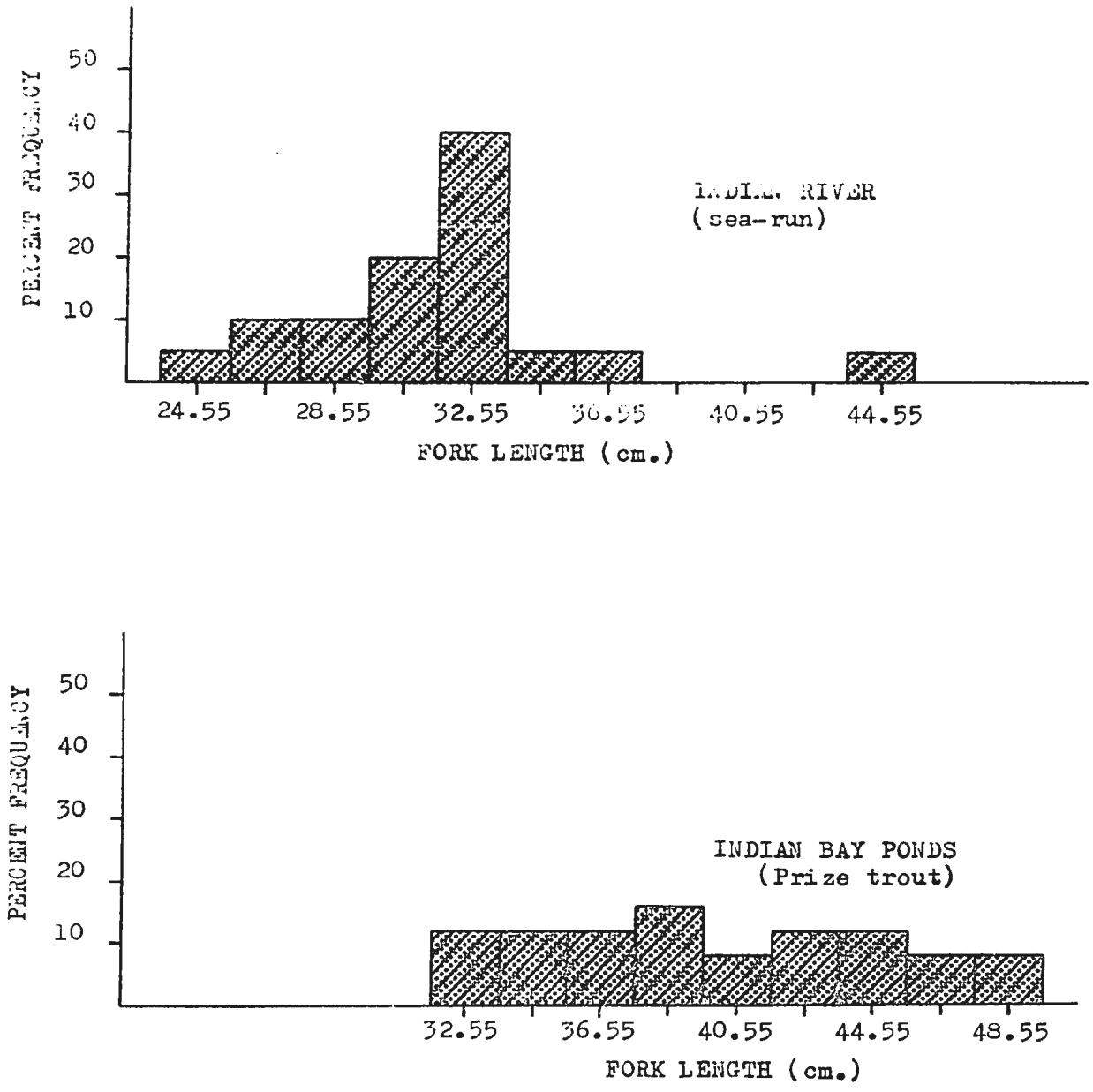


FIGURE III. 1 d. Fork length distribution of Indian River sea trout and Indian Bay Prize speckled trout.

lengths are presented graphically in a manner prescribed by Hubbs and Perlmutter (1942) and modified by Hubbs and Hubbs (1953). Figure III. 2 shows the presentation. The sampling areas are arranged in order of habitat size (stream, river, pond, lake, and the sea).

For each sample the horizontal line represents the range of variation; the single vertical line represents the arithmetic mean ($\bar{x}$); the hollow rectangle represents one standard deviation about the mean (S.D.); and the solid rectangle indicates twice the standard error on either side of the mean ($2\ \sigma_m$). Hubbs and Perlmutter (1942) indicated that considerable reliance could be placed on the significance of the difference between samples, if the solid rectangles ($2\ \sigma_m$) are only slightly separated or if the overlap is not more than about 33 percent of the length of the shorter rectangle. When the longer rectangle is 2 to 4 or more times as long as the shorter one, an overlap of as much as 50 or 75 percent does not remove the probability that a significant difference exists. If the gap between rectangles exceeds 10 percent of the length of the shorter rectangle, a significant difference should be regarded if we assume the sample to be representative. Furthermore, when two samples having normal variation are compared, if the hollow rectangles (S.D.) neither overlap nor are separated on the ordinate scale, an overlap in frequencies of only about 16 per cent is indicated; that is, 84 per cent of the individuals of both groups would then be separable.

When the length frequencies of males and females are compared in Table 1 Appendix I, we see no great differences in composition; the modal classes for both sexes are for the most part the same. The only exception is Angle Pond, where the modal class for males is 20.55 cm., while for females

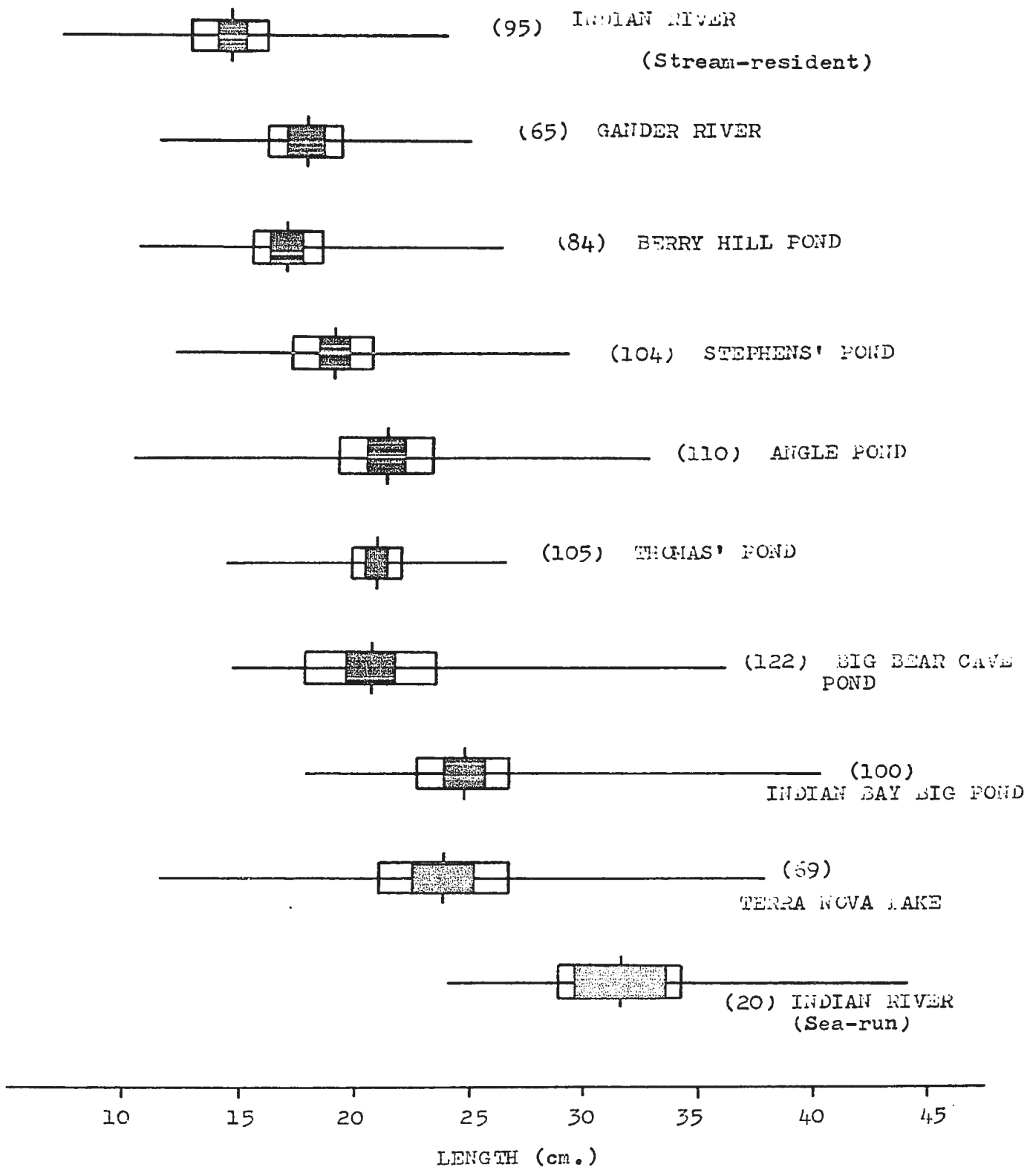


FIGURE III. 2. Graphical comparison of fork length data for speckled trout from various localities studied.

TABLE III. 1. Comparison of mean fork length (cm.) by sexes for speckled trout from all localities studied.

Locality	SEX	MEAN LENGTH (cm.)	S.D.	S.E.	P. VALUE
Berry Hill Pond	male	16.29	2.632	0.3615	0.09
	female	17.52	3.496	0.6278	
Stephen's Pond	male	18.21	2.092	0.3267	0.038*
	female	19.22	2.872	0.3618	
Angle Pond	male	20.93	4.456	0.6431	0.66
	female	21.26	3.262	0.4142	
Thomas' Pond	male	20.68	2.374	0.3462	0.85
	female	20.76	1.786	0.2344	
Big Bear Cave Pond	male	21.70	6.162	0.8385	0.059
	female	19.73	5.128	0.6218	
Indian Bay Big Pond	male	24.92	5.076	0.6664	0.29
	female	24.02	3.508	0.5412	
Indian River (Stream-resident)	male	14.14	2.954	0.3845	0.54
	female	14.55	3.242	0.5403	
Indian River (sea-run)	male	30.40	2.427	0.8090	0.16
	female	32.66	4.339	1.3081	

*Significant at α = .05

it is 22.55 cm; for all other areas males and females both have the same modal length class.

However, to statistically determine if there was evidence for sexual dimorphism in size (length), the differences in the mean lengths between the sexes were tested using the "Z test" statistic when the sample size was over 30, and the "t test" statistic when a small sample was involved (less than 30). The results are shown in Table III. 1. In all areas except Big Bear Cave Pond and Indian Bay Big Pond, females had greater mean lengths. However, when these means were tested statistically, only Stephen's Pond showed a significant difference ($p = 0.038$). Since the difference was only significant at a probability of 0.05, it was felt that this did not justify a statement to the fact that a definite sexual dimorphism existed in Stephen's Pond.

B. Weight

Whole weight measurements are shown in Table 2 Appendix I, where the fish are grouped into 30 gm. weight classes. The whole weight distributions are presented in histogram form in Figure III. 3 (a-c).

The whole weight distributions, like the length distributions, are for the most part unimodal and positively skewed. The exceptions are Big Bear Cave Pond, where a hint of bimodality exists due to sampling; and Indian River, where the sea-run trout show a bimodal distribution, undoubtedly the result of a small sample (20).

Once again, as was the case with length, the whole weight distribution shows a definite shift to the right with increase in the size of the body of water. Again, the greatest range in weight, and the heaviest fish are found in the larger bodies of water. Figure III. 4 shows the increase in mean whole

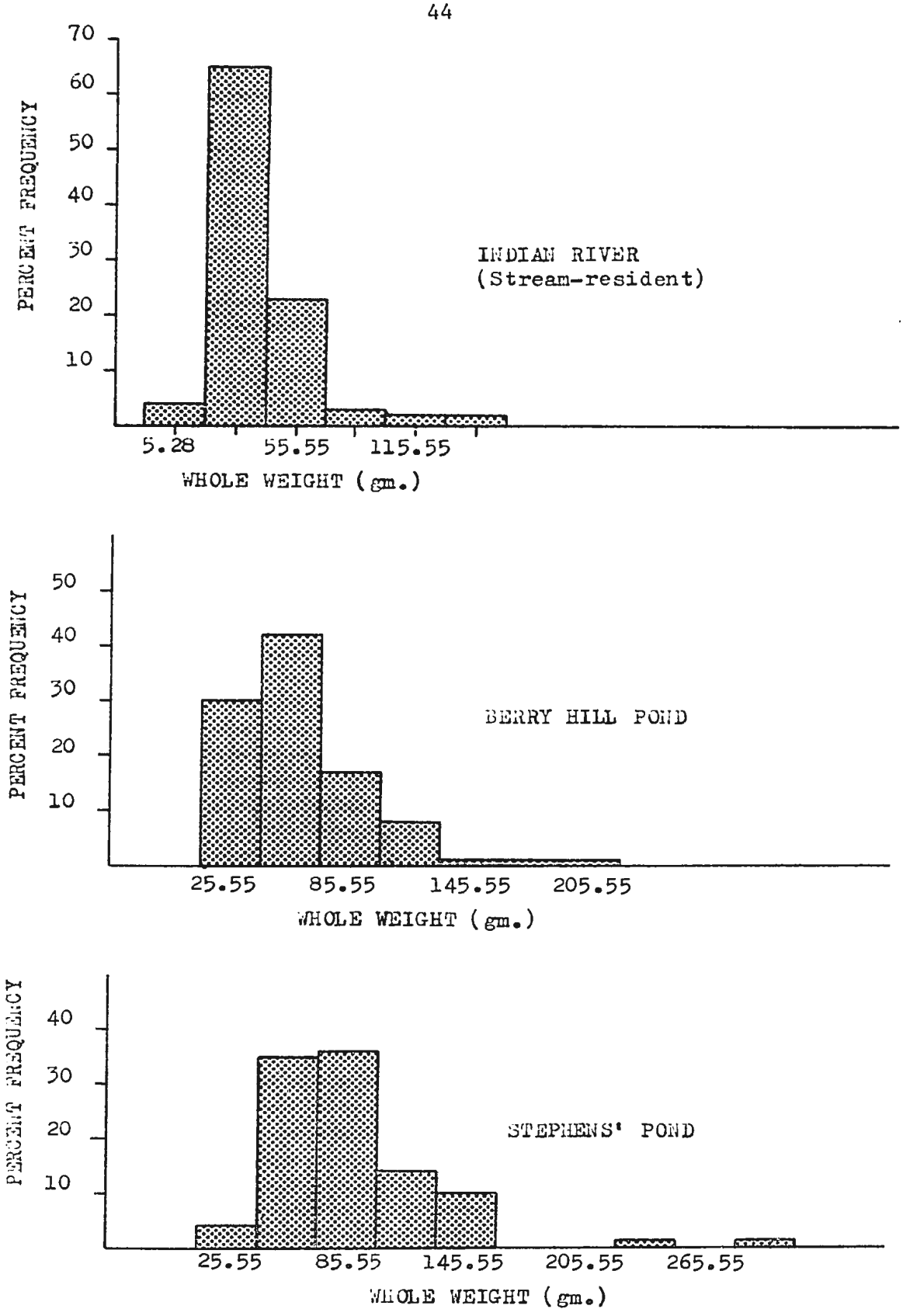


FIGURE III. 3 a. Whole weight distribution of Indian River, Berry Hill Pond, and Stephen's Pond speckled trout.

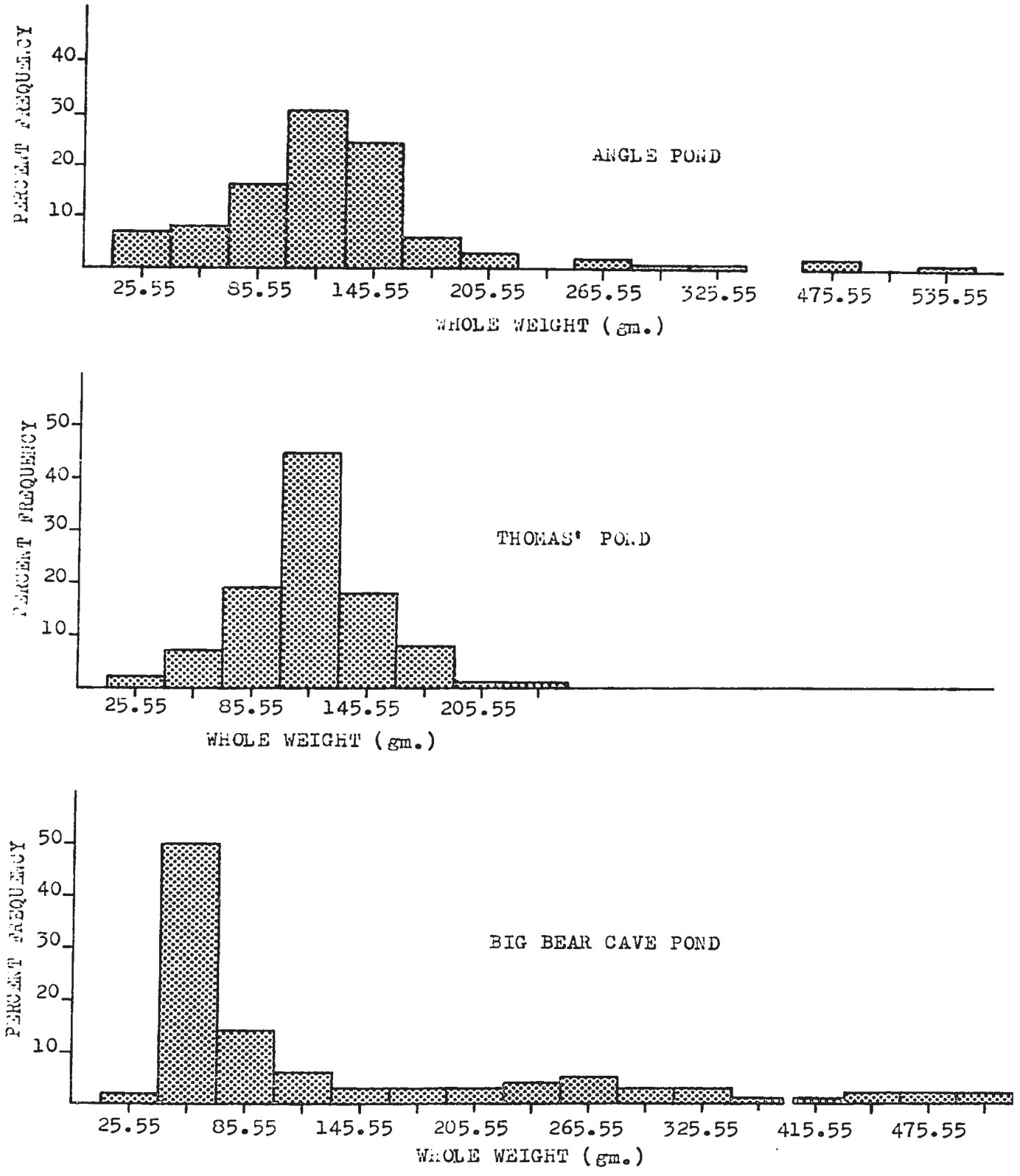


FIGURE III. 3 b. Whole weight distribution of Angle Pond, Thomas' Pond, and Big Bear Cave Pond speckled trout.

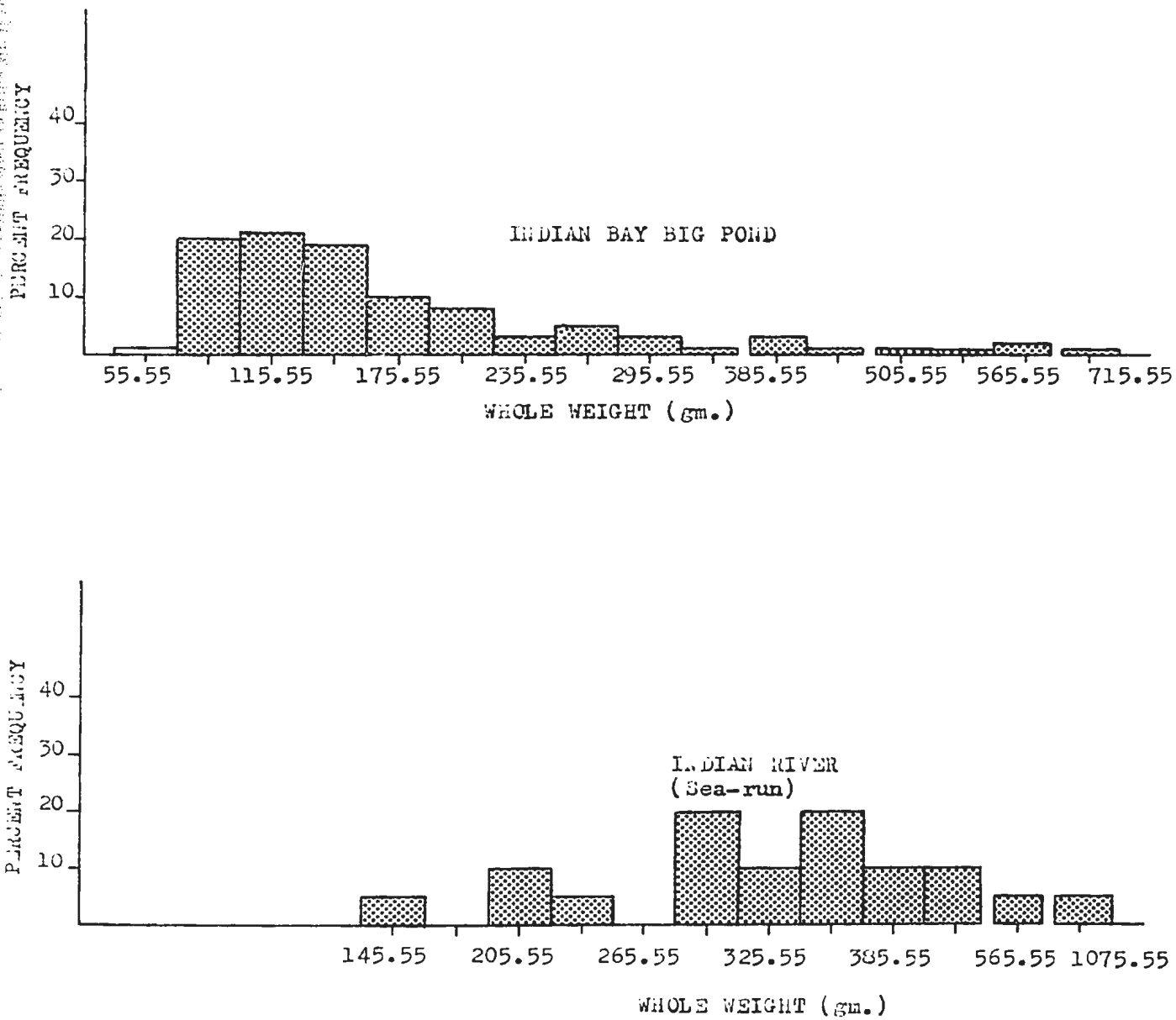


FIGURE III. 3c. Whole weight distribution of Indian Bay Big Pond speckled trout and Indian River sea-run trout.

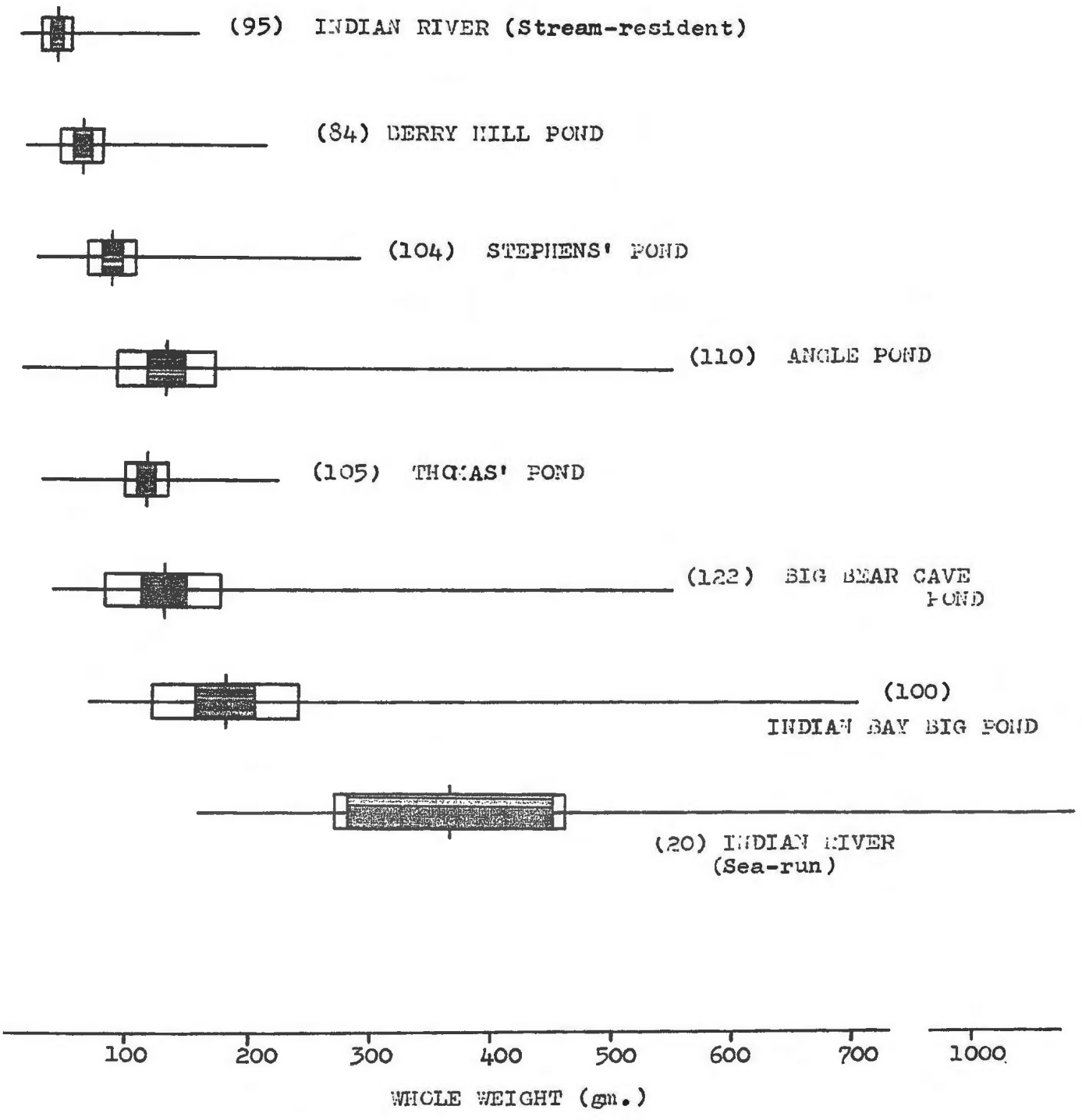


FIGURE III. 4. Graphical comparison of whole weight data for speckled trout from the various localities studied.

weight with increase in the surface area of the habitat. Table 2 Appendix I shows that no difference exists in whole weight distribution between the sexes for the most part. Generally, both sexes have the same modal weight class, with only Stephen's Pond, Indian Bay Big Pond, and Indian River sea trout showing differences. The small sample size is responsible for the discrepancy of the Indian River distribution. The modal classes for both Stephen's Pond and Indian Bay Big Pond female trout are shifted one class to the right of the male modal classes.

To determine if sexual differences in whole weight were present, the differences between the sexes were tested statistically. Table III. 2 shows that in all areas except Angle Pond, Big Bear Cave Pond, and Indian Bay Big Pond, the mean whole weights of females are greater than those of males; when tested however, no significant differences were found.

Gutted weights were then used to exclude the variables gonad weight and weight of stomach contents which are influenced by season, locality, and sex.

Gutted weight distributions are shown in Table 3 Appendix I, where the fish are grouped into 30 gm. weight classes.

The distributions are generally the same as those for whole weight; unimodal, positively skewed, but shifted slightly more to the left.

Figure III. 5 shows graphically that the mean gutted weights increase with an increase in the size of the body of water. Table 3 Appendix I shows that little or no difference exists in distribution between the sexes. Table III. 3 shows no significant difference for the mean gutted weight between the sexes.

TABLE III. 2. Comparison of whole weight (gm.) by sexes for speckled trout from all localities studied.

LOCALITY	SEX	MEAN WEIGHT (gm.)	S.D.	S.E.	P. VALUE
Berry Hill Pond	male	55.55 (53)	30.570	4.1991	0.085
	female	70.07 (31)	40.890	7.3437	
Stephen's Pond	male	78.23 (41)	29.835	4.6595	0.064
	female	91.74 (63)	44.490	5.6053	
Angle Pond	male	138.05 (48)	102.660	14.8181	0.35
	female	122.81 (62)	51.960	6.6022	
Thomas" Pond	male	113.00 (47)	39.960	5.8284	0.42
	female	118.65 (58)	30.600	4.0178	
Big Bear Cave Pond	male	151.11 (54)	129.660	17.6408	0.077
	female	112.46 (68)	105.840	12.8290	
Indian Bay Big Pond	male	191.58 (58)	137.100	18.0015	0.25
	female	165.55 (42)	89.310	13.7824	
Indian River (Stream-resident)	male	37.57 (59)	23.640	3.0781	0.16
	female	38.59 (36)	33.600	5.6000	
Indian River (Sea-run)	male	314.02 (9)	120.000	40.0000	0.25
	female	406.42 (11)	231.300	69.7316	

TABLE III. 3. Comparison of gutted weight (gm.) by sexes for speckled trout from all localities studied.

Locality	Sex	Mean Weight (gm.)	S.D.	S.E.	P. Value
Berry Hill Pond	male	50.46	28.662	3.9370	0.19
	female	60.39	35.280	6.3362	
Stephen's Pond	male	71.65	24.279	3.7918	0.19
	female	79.36	35.400	4.4584	
Angle Pond	male	122.43	74.190	10.7087	0.33
	female	110.71	46.470	5.9010	
Thomas' Pond	male	103.42	35.190	5.1327	0.71
	female	105.72	26.748	3.5120	
Big Bear Cave Pond	male	138.88	115.650	15.7380	0.051
	female	101.43	93.360	11.3210	
Indian Bay Big Pond	male	171.92	125.400	16.4730	0.15
	female	143.40	72.990	11.2620	
Indian River (stream-resident)	male	35.54	23.262	3.0285	0.73
	female	34.42	33.600	5.6000	
Indian River (sea-run)	male	295.55	105.960	35.3200	0.26
	female	369.19	184.620	55.6587	

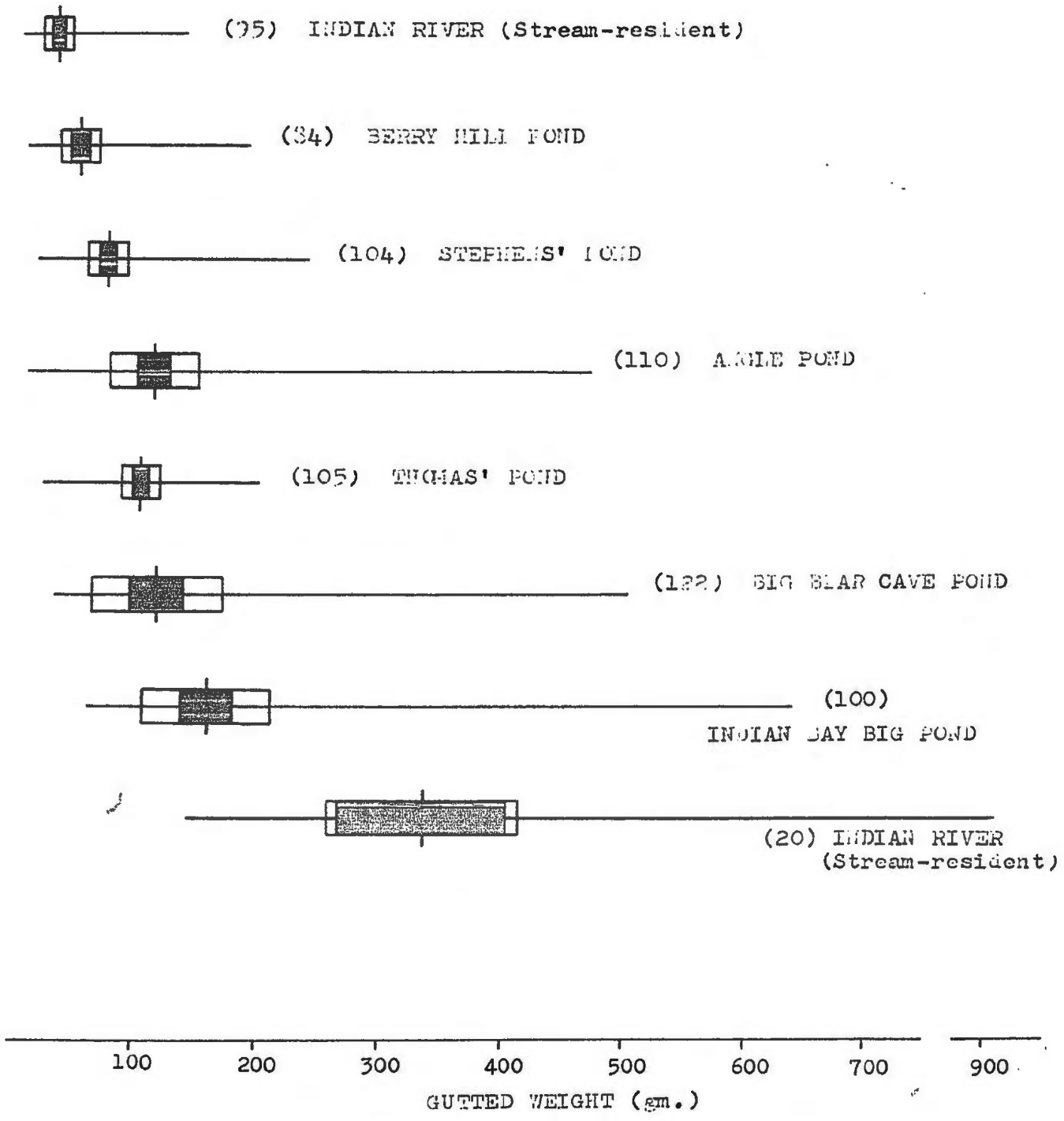


FIGURE III. 5. Graphical Comparison of gutted weight data for speckled trout from the various localities studied.

To conclude the discussion on size composition, it can be said that generally size distributions are unimodal, not indicating year class dominance, positively skewed to the right; shifted to the right as the habitat size increases; and not exhibiting any difference between the sexes. In general, the mean size increases with increased surface area of the habitat, and no sexual dimorphism in size is exhibited.

IV. Age Determination

A knowledge of the age composition of a fish population is essential to any study because of its importance in determination of such factors as life span, growth rates, fecundity, and age at first spawning.

The fact that information on the age and growth rate of speckled trout was scant up to and for some years after the turn of the century is exemplified by Agassiz' classical reply to the question regarding the age of large speckled trout. ". . . no man living could tell, they might be 10 to 200 years old." (Kendall, 1914).

Information was still scanty and crude twenty or thirty years later. "It takes perhaps ten or fifteen years to produce a four or five pound trout under natural conditions. Who actually knows?" (Kendall and Dence, 1929).

A. Methods

Three general methods have been employed to estimate the age of fish. The first method is a comparison of length frequency distributions (Petersen's Method) of samples containing fish of more than one age group. The second is the mark-recapture technique. The third involves the recognition and interpretation of periodic markings laid down in the hard parts of the fish such as scales, otoliths, fin rays, vertebrae, opercular bones, bones of the pectoral girdle, and various skull bones.

1. Petersen's Method

Petersen's method has been in use since 1891. Essentially it involves statistically breaking the polymodal length frequency distribution into its

constituent "normal" components. The age at first capture by the sampling gear must be known to assign ages to successive modes. Petersen's method is more a population technique and an indirect one; individual fish cannot be aged. Because it has several limitations, it is generally replaced by direct methods. However, Petersen's method is often used to validate other methods.

2. Mark-recapture Method

The mark-recapture method is the most direct and certain way of age determination. It simply consists of marking or tagging a fish of known age and then at some future time when it is recaptured, there is no doubt as to its age. This method is of a limited value because of the time involved and the low percentage of recovery; however, it is an excellent method to validate other methods (Rounsefell and Everhart, 1953).

3. The Use of Annual Marks on Hard Parts

The most generally accepted method of age determination is interpretating the annual markings or layers deposited in the hard parts of the fish. The most widely used structure is the scale, with the otolith and other bones following in that order. This method is dependent on changes in growth rate or metabolism during certain periods of the year as witnessed in these hard parts. Accurate age determination requires the recognition and the ability to interpret these layers or markings correctly. This method has been in use since the late 1890's, with the scale being the first structure used extensively. (Rounsefell and Everhart, 1953).

(a) Scales

(1) Conditions for the use of scales in age determination

Van Oosten (1929) listed three conditions on which the scale method of age determination is founded. The latter two of these conditions are applicable to other bony structures used in age determination. The conditions are as follows:

(i) The scales must remain constant in number and identity throughout the life of the fish. The fact that the focus of scales from young fish is identical with that of older fish proves that the identity remains constant throughout life. The fact that scale counts are used in species differentiation shows that the number of scales remains constant throughout life.

(ii) Growth of the scale must be proportional to the growth of the fish. A linear relationship rarely exists between scale growth and body growth, but good agreement has been found for growth of different age groups of the same year class, and among different year classes for growth in a certain year..

(iii) The annulus must be formed yearly and at the same approximate time each year. It has been shown that there is a definite correlation between age and growth, with the number of annuli increasing as the fish grows older. Also Petersen's method of length-frequency analysis has shown that length-frequency modes coincide with modal lengths of age groups based on scale interpretation.

(2) Limitations to the scale method

There are however limitations to the scale method which must be kept in mind.

(i) "False" annuli may be formed due to extreme environmental conditions at a certain period of the year, or to physiological changes within

the fish itself (spawning, injury, or starvation). In both cases growth may be accelerated or retarded as the case may be, so as to cause incorrect interpretation of the periodic markings or "checks" on the scale.

(ii) It may be difficult to establish the first year zone due to rapid growth in the early years of life.

(iii) Growth, especially in the latter years, may be so slow that the annuli become crowded together and difficult to distinguish.

(3) Reliability of the scale method

Many investigations have been carried out with regard to determining the validity and reliability of the scale method;; most of the investigations are included in the following categories: (i) mark-recapture experiments, (ii) aquaria experiments, (iii) agreement with the Petersen method, (iv) the use of marked structures such as abnormal scale or otolith characters which may occur in a particular year class, (v) agreement between age readings of other skeletal parts from the same fish, for example, one validated method (scales) may be used to validate another (otoliths), (vi) seasonal changes in the structure at the edge of the scale, i.e., following seasonal changes in the deposition of circuli, and (vii) the use of back-calculated growth from scale reading.

(b) Otoliths

Although the teleost fish has six otoliths, three on either side, only one from either side is usually taken for age determination. This is the sacculotolith (sagitta) which is found in the sacculus of the piscine labyrinth. The otolith is calcareeous and its structure is laid down in concentric layers. Otoliths are either read whole or sectioned, in reflected

or transmitted light depending on the species concerned. When read in reflected light, the wide summer bands appear opaque, and the narrow winter bands translucent, and vice versa for transmitted light.

The conditions for the use of otoliths in age determination are similar to those for scales.

Besides the limitations which otoliths have in common with scales, they have other particular limitations as follows: (1) the otolith may be too small or too irregular, and (2) it necessitates killing the fish and the method cannot be validated by mark-recapture methods.

Otoliths can, however, be validated by many of the methods discussed for scale validation.

Otoliths are usually used in age determination in conjunction with scales (usually as a check on scales), or when the use of scales is impossible because of lack, unsuitability, or regeneration.

B. Age Methods in the Present Study

Both scales and otoliths were used to age speckled trout in this study. For the most part otoliths were used as a check on scale reading or in instances when scales were not available, not able to be read, or regenerated.

1. Otoliths

(a) Structure

The speckled trout otolith is a laterally compressed, oval structure, formed essentially of aragonite crystals and an organic network. No reference could be found concerning the chemical composition of the speckled trout otolith, but Dannevig (1956) reports that in the cod otolith the hyaline winter bands contain only inorganic compounds, while the opaque

summer zones are a mixture of calcium compounds and organic matter.

Anteriorly, the otolith is deeply cleft into a long, prominent, ventral rostrum and a much shorter, less prominent, dorsal anti-rostrum. The posterior edge is rather blunt and rounded, and is slightly indented at the mid-line. Both surfaces taper outward in all directions to a thin edge. The margins are irregularly indented.

(b) Methods

The right and left otoliths were used whenever possible. These were cleaned, mounted in a mixture of glycerine and water in a petri dish and read in reflected light using a binocular microscope. In the speckled trout otolith viewed in reflected light, the wide opaque bands represent summer growth, and the narrow, translucent hyaline bands the winter growth. The hyaline winter growth zones were counted and expressed as years, the partial opaque band forming at the perimeter was referred to as plus growth. Therefore, an otolith taken in July, showing three hyaline bands and a partial opaque band would be aged as III^{+} years (Figure IV. 1).

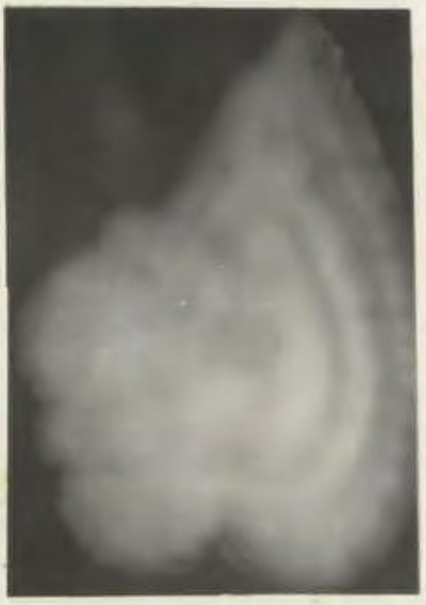


FIGURE IV. 1. Otolith of a III^{+} years old speckled trout viewed in reflected light.

(c) Validation

Otoliths have replaced scales in age studies of such fish as plaice (Wallace, 1915 and Berry, 1959); hake (Hickling, 1933); redfish (Kelly and Wolf, 1959); sturgeon (Harkness, 1923 and Greeley, 1937); shad (Barney, 1925); cod (Dannevig, 1933 and Rollefsen, 1933); haddock (Saetersdal, 1953); and capelin (Pitt, 1958). However, nowhere in the literature could reference be found to the use of otoliths for age determination in speckled trout. In fact, the use of otoliths for age determination in the Salmonidae as a whole is rare and only two instances come to mind. Grainger (1953) and Andrews and Lear (1956) both used otoliths to age Arctic char.

The rare usage of otoliths to determine age in the Salmonidae is undoubtedly due to the fact that the scale method has been validated and in use for some time in connection with age studies on the Salmonidae. Since otolith readings were compatable with scale readings which have been validated, otoliths were indirectly validated as a means of age determination in the speckled trout.

2. Scales

(a) Structure and Development

Speckled trout have small embedded cycloid scales which cover the entire body except for the head and fins. They are thin, somewhat elliptical in shape, and shightly concavo-convex. Circuli, more or less concentric, are laid down on the outer surface; the focus is relatively large and is permanently centrally located; there are no radii (Figure IV. 2).

The scales of speckled trout vary considerably in size and shape with locations on the body. The largest scales are found on the caudal peduncle (where scales first appear), and the smallest ones on the throat.

FIGURE IV. 2. The scale of a III^{+} years old speckled trout showing three annuli plus summer growth.

They also vary in size and shape within a given area of the body.

In examining a series of scales, irregularities are frequently found. The most common irregularity is regenerated (latinucleate) scales in which the clear, well-defined focus of a normal scale is replaced by an expanded central area, lacking circuli, rough or granular in appearance and somewhat irregular in outline. Although future scale growth is normal, the regenerated scale is of no use in age determination. Allen (1956) reports a high percentage of regeneration in speckled trout scales and suggests that the right side of the caudal peduncle has a higher percentage than the left, and that males have a higher percentage than females.

Other irregularities occur when a young scale becomes loosened slightly in its scale pocket; this results in the appearance of a smaller scale off center in a larger scale. Finally, in some instances, two scale papillae may grow together and result in one scale with two foci.

Young-of-the-year fry hatched in April and which are the result of spawning in the previous October to November period reach a length of less than 25 mm. (Cooper, 1951). Elson (1939) reports that it is at this length that the first evidence of scales may be seen in the form of small scale papillae. These scale papillae and the scales proper do not develop at the same time over the whole body. They begin to appear first along the lateral line from the head to the level of the adipose fin. Further development is fastest in the region of the caudal peduncle.

Tiny scale platelets now develop within the papillae. They are thin discs with slightly concave inner surfaces and convex outer surfaces. The platelets are soon surrounded by additional material and then the first circulus is laid down. (Figure IV. 3.)

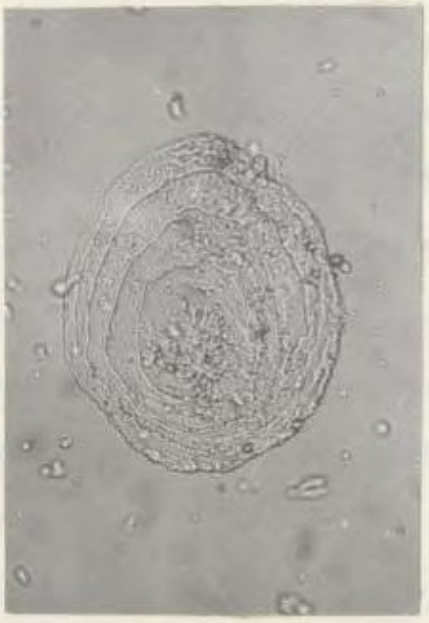


FIGURE IV. 3. Scale platelet of a 4.0 cm. speckled trout showing the first three circuli deposited.

(b) Definition of annulus

Cooper (1951) in discussing the definition of the annulus of speckled trout scales stated, "the crowding of adjacent circuli, irregularity or incompleteness in their formation, and the 'cutting over' of circuli in the postero-lateral areas, are the chief characteristics that have been employed."

In this present study, no one characteristic as mentioned by Cooper could be consistently applied in distinguishing the annulus and generally a combination of these characteristics had to be used. The rate of growth differed so much between summer and winter that summer growth produced zones where the circuli were laid down well spaced, while the winter growth zone saw thin, crowded circuli laid down. This was generally the most consistent characteristic of an annulus. Also, associated with the zones of crowded circuli were incompletely formed circuli and often these crossed over one another, or as Cooper (1951) called it "cutting over". These characteristics, then, defined the annulus. Because of the methods used in determination of the annulus, a little subjectivity is introduced in this aging procedure. Since the annulus is not always the same for all areas studied, practice, patience, experience, and knowledge of the general biology of the species are often needed to distinguish true annuli.

The exact limit of the annulus is the last laid crowded circulus before the first widely spaced circulus which indicates resumption of rapid summer growth. An important but often overlooked fact as stated by Cooper (1951) is that "the annulus must be formed and summer growth begun anew before the annulus can be identified.

(c) Time of Annulus Formation

Both Cooper (1951) and Allen (1956) state that in Michigan annulus formation occurs in April, May, or as late as June, depending on the locality, water temperature, and perhaps on age and rate of growth. For example in the European trouts (Salmo sp.) the older and slower growing individuals formed annuli later than younger, faster growing fish (Numann and Sella, 1943). Baldwin (1948) and McFadden (1959) found the same for speckled trout. McFadden found that by the middle of April in a Wisconsin stream 74% of one year olds had formed the annulus, 63% of the two year olds, and only 30% of the three year olds.

In Newfoundland waters annulus formation is generally completed in April and May and scale growth is advanced by June with four or five wide spaced circuli having been laid down. This was determined from the fact that all scales examined from fish taken in June had a clear annulus with several successive wide-spaced circuli. This may be due to the fact that annulus formation begins earlier in more northern latitudes and therefore ends earlier.

Fastest scale growth usually occurs during late May and June; the circuli are at this time prominent and wide spaced. By the end of July, these circuli are being laid down more closely together. Through August the closeness of the circuli continues progressively until by early September five or six circuli occupy as little space as perhaps did two or three of them in May and June. We can generally say that annulus formation begins at this time and very little change in the appearance of the circuli occurs until the following April or early May when annulus formation is complete and the pattern of fast growth is again repeated. Allen (1956) reports that trout taken on September 9th in Wyoming showed annuli in the process of formation.

(d) False Annuli

False annuli or "checks" often appear on speckled trout scales (Cooper, 1951 and Hatch, 1961). A common cause is a mid-season rise in water temperature approaching the lethal thermal limit. The check often resembles a true annulus, but it can usually be distinguished because it appears in the same relative position in all age classes, and the expected true annulus forms in its normal position in spite of the previous check.

These false annuli or checks may be particularly common in hatchery reared trout where seasonal environmental changes may not be as drastic. Hatch (1961) reports that as many as 65 to 90% of speckled trout in four Adirondack lakes had false annuli. He suggests two reasons: (1) the trout were stocked from hatcheries and probably already had "hatchery checks", and when released a "stocking check" occured from a rapid increase in growth, and (2) probably due to the fact that in all four lakes surface temperatures exceeded the optimum range for growth.

Spawning checks which normally occur on many fish scales are no problem in speckled trout as they coincide with the formation of the true annulus.

In this study, false annuli were not considered to be present.

(e) Methods

Small scale scrapings were taken from a key location on the fish. The scales were removed from an area on the left side just above the lateral line and at the level of the adipose fin (or just anterior to the caudal peduncle). Scales were taken from this region for two reasons. Firstly, as Allen (1956) points out, the frequency of regeneration is lowest in this area, and secondly, whenever scales are removed from a particular area, for obvious

reasons it must be determined whether scales fail to appear in this area before the time of first annulus formation. In the golden trout (Salmo agua-bonita) for example, some individuals do not form scales until the second year (Curtis, 1935). In the Yellowstone cutthroat trout (Salmo clarki lewisi) Robertson (1947) reports that as many as two-thirds of the population may show no first year annulus. This phenomenon is usually associated with slow growth. However, both Cooper (1951) and Allen (1956) have shown that young-of-the-year speckled trout have scales by September and since these first appear along the lateral line at the level of the adipose fin, scales are indeed present in this area before the time of first annulus formation.

A number of scales were cleared by rubbing them between the fingers then mounted dry between two microscope slides which were held together with strips of cellulose tape. Then using a Bausch and Lomb microprojector, the scale image was projected onto a sheet of white cardboard with a magnification of X 43.

The age was determined using the previously mentioned criteria for annulus recognition. The thin and crowded winter circuli representing the annulus, were counted and expressed in years, and the partial summer growth composed of widely spaced circuli was referred to as "plus growth" for the year in which the sample was taken. For example, a scale taken in July showing three annuli and several wide spaced circuli at the perimeter was recorded as showing III^{+} years (Figure IV. 2).

The writer personally found that speckled trout scales were quite easily read after a little experience. The only difficulty encountered was the fact that many of the older fish were found to have mainly regenerated

scales. In these instances otoliths were relied upon.

Determination of age was made without prior reference to the size of the fish to avoid introducing bias. The scales were read twice, at different times, and then checked with otoliths.

Errors in age reading increase with the age of the fish. As growth slows down, the circuli become progressively more crowded together and annulus determination becomes more of a problem. Error may be introduced in the location of the first annulus when growth was rapid in the first couple of years of the fish's life. Age may be very difficult to determine if the fish is sampled during the period of annulus formation; some may show it on the scale margin, others may not.

(f) Validation of the Scale Method

Cooper (1951) states, "In view of the wide application and general acceptance of the use of scales for age determination in fishes, it perhaps seems a bit academic to test the validity of the method for the brook trout."

Other members of the Salmonidae, however, were among the first fishes to be aged with scales, and the validity has been since shown.

The first recorded aging of speckled trout by the scale method was by Kendall and Dence (1927); they determined the age of trout from various streams in Allegany State Park, New York.

Since their first use, scales have been used by many workers in age determination for speckled trout assuming that the method as used for other salmonids could also be used for this species (Hazzard, 1932, 1935; Greeley, 1934-1940; Cooper, 1940; Rawson, 1941; Smith, 1941; Shetter and Leonard, 1943; Cooper and Fuller, 1945; Doan, 1948; and Baldwin, 1948).

Notwithstanding its wide application, several workers have doubted the accuracy of the scale method for speckled trout. (Kendall and Dence, 1927; Ricker, 1932; and King, 1942). They have based their doubts on four reasons: (1) the scales are minute and difficult to read, (2) a high percentage of older scales are regenerated, (3) relatively large foci may be difficult to distinguish from regenerated areas, and (4) in some instances, summer and winter differences in scale growth are not distinct.

However, both Cooper (1951) and Alvord (1953) have validated the use of scale reading in speckled trout by using fish of known age which were periodically sampled and the known age was compared with the age determined by annulus count.

Then in 1956, Allen validated the scale method by applying the criterion developed by Petersen in 1895.

C. Back-Calculation of Growth

As was previously mentioned, one of the conditions or assumptions on which the scale method is based is that the annual increment in the length of the scale maintains, throughout the life of the fish, a predictable ratio to the annual increment in body length (Van Oosten, 1929). Therefore it is the purpose to show that such a relationship indeed does hold for speckled trout, and that the scale method is valid for the species in the Newfoundland area.

1. Body-Scale Relationship

The earliest method assumed that the relationship between body length and scale length was a simple proportionality expressed as $L = cs$, where L is the body length, s scale length, and c a constant. This has come to be known as the Dahl-Lea direct proportion method. This method

suggested a straight line relationship with the origin passing through zero.

However, it is doubtful that a straight line relationship exists throughout the life of a fish; it may for earlier life. More important however, is the fact that the straight line seldom passes through the origin since the young fish has usually attained a certain length before squamation begins. Thus a correction must be introduced to compensate for this and the regression now becomes $L = a + cs$, where $\underline{a}$ is the correction factor. This is known as the Lee Method.

Rather than determine the actual value of $\underline{a}$ by observing the time of scale formation, the regression line is simply extrapolated back and the value of $\underline{a}$ is where the line cuts the body length axis. However, caution should be used in the interpretation of $\underline{a}$ since it often takes a negative value, which would suggest the fish has a negative length at scale formation. In some species, this interpretation may be approximately correct, but it should not be used as a generalization (Monastyrsky, 1930).

Sherriff (1922) suggested the relationship to be parabolic and expressed by the equation $L = a + bs + cs^2$ where $\underline{a}$, $\underline{b}$, and $\underline{c}$ are empirically determined constants.

Monastyrsky (1930) suggested that the logarithms of fish length and scale length exhibit a straight line, or that $\log L = \log c + n \log s$, or expressed in exponential form $L = cs^n$.

Fry (1943) modified the Monastyrsky equation by adding the constant $\underline{a}$, yielding $\log (L - a) = \log c + n \log s$. The introduction of $\underline{a}$ however, creates the difficulty that a mathematical fitting of the equation is impractical.

For purposes of validating the age reading of speckled trout in this study, one area, Angle Pond, was chosen because it offered the best range and distribution of age of all areas studied (Figure V. 5.).

Using a microprojector with a magnification of 43 diameters, the scales were measured to the nearest tenth of a centimeter (magnified length). The distance from the center of the focus to the approximate mid-point of the anterior margin of the scale (anterior scale radius) was used as the scale length. Measurements from the center of the focus to the annuli were made along the same radius.

In the majority of studies of back-calculation, the lengths have been computed for each individual fish, and the average growth rates for any particular group obtained from the data. However, Van Oosten (1929 and 1958) has shown that the same information is obtained by averaging the scale lengths for each year of life and the lengths of the fish concerned, and calculate average lengths from these data. This was the method employed in this study.

Hazzard (1932) assumed the body-scale relationship was linear with the correction factor corresponding to the length at scale formation. Shetter and Leonard (1943) used the direct proportion method in their study. Cooper (1952) found that for speckled trout in Michigan waters the body-scale relationship could best be expressed as a curve; he used the Monastyrsky method, expressing the relationship in the logarithmic form.

The body-scale relationship for Angle Pond is seen in Table IV. 1. When plotted (Figure IV. 4), the data do not show a linear relationship, but a curvilinear relationship along the entire range of the values.

TABLE IV. 1. Body-scale relationship for Angle Pond speckled trout.

Length Class	Number	Average Fork Length (cm.)	Average Scale Length X43 (cm.)
9.55 - 11.55	2	10.50	1.60
11.55 - 13.55	3	12.23	1.80
13.55 - 15.55	5	15.14	2.05
15.55 - 17.55	4	16.78	2.30
17.55 - 19.55	12	18.75	2.36
19.55 - 21.55	34	20.50	2.68
21.55 - 23.55	30	22.44	2.92
23.55 - 25.55	12	24.38	3.24
25.55 - 27.55	3	26.57	3.20
27.55 - 29.55	2	28.60	3.80
29.55 - 31.55	1	30.90	4.70
31.55 - 33.55	2	32.15	4.50

The Monastyrsky logarithmic method was used to fit the data and straighten out the regression. Back calculation of lengths was then made directly from the equation $Ln = 7.263\ sn^{1.0133}$

Because fish lengths are calculated from scale measurements, the regression of fish length on scale length is the correct one to use, instead of the regression of scale length on fish length, which is generally used. The importance of this distinction has been emphasized by Weymouth, McMillan, and Rich (1925).

In recent years, most workers have come to realize that the piscine body-scale relationship is rarely linear; indeed a linear relationship is the exception. In the Salmonidae as a whole, the following authors have found curvilinear relationships: Cooper (1952), for speckled trout;

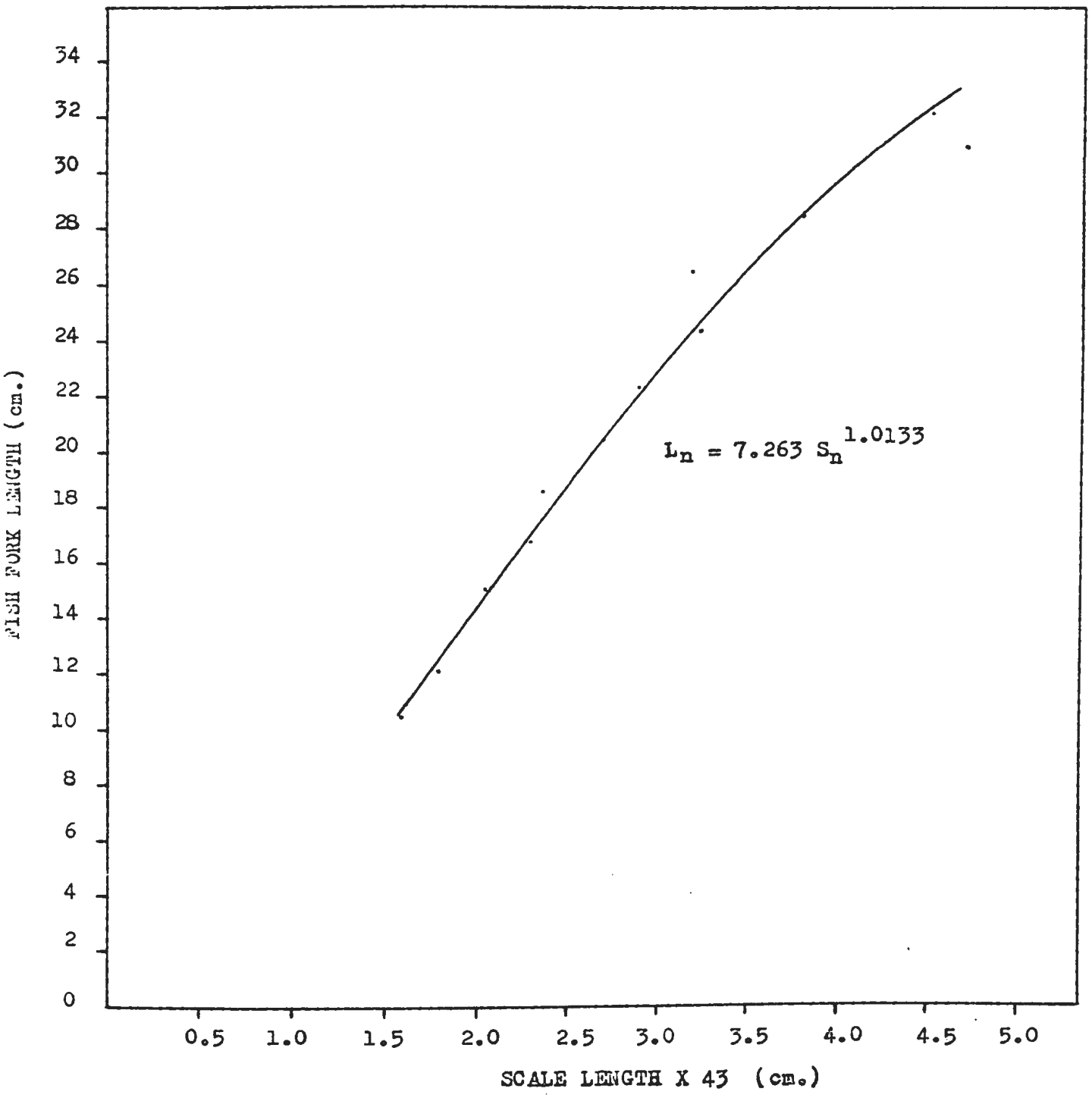


FIGURE IV. 4. Body length - scale length relationship for Angle Pond speckled trout.

Sigler (1951) and Kipling (1962), for brown trout; Fleener (1951) and Irving (1954), for the cutthroat trout; Bjornn (1961), for the Dolly Varden trout; Kerr (1961), for the Atlantic salmon; Marr (1943), for the chum salmon; and Dunlop (1924), for the sockeye salmon.

As was previously mentioned, to be valid in age determination, scale growth must show a proportionality to fish growth, and this relationship should show good agreement for growth of different age groups of the same year class, and among different year classes.

The agreement between actual lengths and back-calculated lengths for various age groups is shown in Table IV. 2. There was no significant difference (Chi-square = 0.499; d.f. = 4).

The agreement of scale growth between year classes and between age groups within year classes is shown in Table IV. 3.

TABLE IV. 2. Comparison of actual length at age n with the calculated length from the body-scale relationship for Angle Pond speckled trout.

Year Class	Age (Yrs.)	Scale Length X43 (cm.)	Fish Length (cm.)	Calc. Fish Length (cm.)
1964	1^+	1.70	12.01	12.44
1963	2^+	2.38	19.18	17.49
1962	3^+	3.01	22.67	22.19
1961	4^+	3.90	29.97	28.85
1960	5^+	4.80	32.50	35.59

TABLE IV. 3. Actual scale length (X43) at formation of the annulus for both age and year classes for speckled trout in Angle Pond.

(Plus growth represents the scale length attained between annulus formation and time of capture).

ACTUAL SCALE LENGTH (X 43) AT FORMATION OF ANNULUS						
	AGE CLASS					
Year Class	I	II	III	IV	V	Plus Growth
1960	1.18	2.15	2.80	3.60	4.35	0.45
1961	1.04	1.97	2.63	3.43	---	0.47
1962	1.05	1.92	2.71	---	---	0.31
1963	1.03	2.02	---	---	---	0.37
1964	1.10	---	---	---	---	0.52

Table IV. 4 shows the good agreement of calculated fish length between year classes and within year class age groups. It would appear that Lee's Phenomenon does not exist in this instance. Lee's Phenomenon is an apparent decrease in growth rate when growth is calculated from the scales of successively older fish.

In the exponential form, because the exponent n determines the slope of the line, the difference between the value of n and 1.0 indicates the amount of deviation of the curve from a straight line. The value of the exponent of the Angle Pond sample was close to one, specifically 1.0133.

TABLE IV. 4. Calculated length (cm.) at formation of the annulus for both age and year classes for speckled trout in Angle Pond. Plus growth represents the length attained between annulus formation and time of capture.

CALCULATED LENGTH AT FORMATION OF ANNULUS						
	AGE CLASS					
Year Class	I	II	III	IV	V	Plus Growth
1960	8.00	15.77	20.62	26.60	32.22	3.30
1961	7.48	14.46	19.35	25.32	---	3.45
1962	7.63	14.07	19.95	---	---	2.27
1963	7.56	14.81	---	---	---	2.71
1964	8.59	---	---	---	---	3.81

Hazzard (1932) in using back calculation growth of speckled trout, used samples taken by angling some time after growth had started anew in the spring, therefore no extensive comparison between actual and calculated lengths at annulus formation was attempted.

In this present study however, this problem was overcome by the use of the term "plus growth" which refers to that growth in both scale and fish length occurring from the time of annulus formation to sampling time. Thus we can calculate the growth of both scale and fish in this time interval. Table IV. 3 shows the increment or "plus scale growth" from annulus formation (April) to sampling time (June). There does not seem to be any consistent difference among the age classes. However the one year

olds show the greatest growth increment as would be expected. In this situation we would expect the "plus growth" increments to be progressively smaller for older age groups. Table IV. 4 shows "plus fish length growth" increments.

V. AGE COMPOSITION AND MORTALITY

A. Age Composition

The age composition of speckled trout from the various areas in Newfoundland is shown in Tables V. 1 - 10.

The data are presented graphically in histogram form in Figures V. 1 - 3.

From the age composition data it would appear that the speckled trout in Newfoundland waters, as in other areas, has a narrow age range in comparison with the other members of the genus *Salvelinus*, and with the other trouts (*Salmo sp.*).

Carlander (1950) gives the following as maximum recorded ages for other members of the genus *Salvelinus*: (1) *Salvelinus namaycush*, the lake trout, $\overline{\text{XLI}}$ years; (2) *Salvelinus alpinus*, the arctic char, $\overline{\text{XXII}}$ years; and (3) *Salvelinus malma*, the Dolly Varden char, $\overline{\text{XX}}$ years.

He also lists maximum recorded ages for the genus *Salmo* as follows: (1) *Salmo trutta*, the brown trout, $\overline{\text{XVII}}$ years; (2) *Salmo salar*, the Atlantic salmon, $\overline{\text{XIII}}$ years; (3) *Salmo clarki*, the cutthroat trout, $\overline{\text{X}}$ years; (4) *Salmo gairdneri*, the rainbow trout, $\overline{\text{IX}}$ years; and *Salmo salar sebago*, the landlocked Atlantic salmon, $\overline{\text{VIII}}$ years.

Figures V. 1 - 3 show that the usual range of age in Newfoundland waters is V^+ years, with fish VI^+ years uncommon, and fish VII^+ and $VIII^+$ years indeed rare.

Hoover (1939), in discussing the age of speckled trout in some New Hampshire streams, stated "Only two trout . . . had four annuli. Hazzard

TABLE V: 1. Age composition of stream-resident speckled trout in Indian River for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	I^+	II^+	III^+	IV^+	N	Mean	Std. Dev.	S.E.
Males and Females	4	51	35	5	95	2.4315	0.6623	0.0679
	4.21	53.68	36.84	5.26	100			
Males	2	31	24	2	59	2.4406	0.6205	0.0807
	3.38	52.54	40.67	3.38	100			
Females	2	20	11	3	36	2.4166	0.7242	0.1207
	5.55	55.55	30.55	8.33	100			

TABLE V: 2. Age composition of speckled trout in Berry Hill Pond for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	I^+	II^+	III^+	IV^+	N	Mean	Std. Dev.	S.E.
Males and Females	1	45	32	6	84	2.5119	0.6491	0.0708
	1.19	53.57	38.09	7.14	100			
Males	1	30	20	2	53	2.4339	0.6010	0.0817
	1.88	56.60	37.73	3.77	100			
Females	---	15	12	4	31	2.6451	0.7119	0.1299
	---	48.38	38.70	12.90	100			

TABLE V: 3. Age composition of speckled trout in Stephen's Pond for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	I^+	II^+	III^+	IV^+	V^+	N	Mean	Std. Dev.	S.E.
Males and Females	1 0.96	28 26.92	71 68.27	3 2.88	1 0.96	104 100	2.7596	0.5633	0.0552
Males	1 2.43	13 31.70	26 63.41	1 2.43	--- ---	41 100	2.6585	0.5698	0.0889
Females	--- ---	15 23.80	45 71.42	2 3.17	1 1.58	63 100	2.8253	0.5766	0.0726

TABLE V: 4. Age composition of speckled trout in Angle Pond for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	I^+	II^+	III^+	IV^+	V^+	N	Mean	Std. Dev.	S.E.
Males and Females	6 5.45	42 38.18	57 51.81	4 3.63	1 0.90	110 100	2.5636	0.6950	0.0662
Males	4 8.33	17 35.41	23 47.91	3 6.25	1 2.08	48 100	2.5833	0.8168	0.1178
Females	2 3.22	25 40.32	34 54.83	1 1.61	--- ---	62 100	2.5483	0.5903	0.0749

TABLE V: 5. Age composition of speckled trout in Thomas' Pond for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	I^+	II^+	III^+	N	Mean	Std. Dev.	S.E.
Males and Females	2	47	56	105	2.5142	0.5390	0.0525
	1.90	44.76	53.33	100			
Males	2	20	25	47	2.4893	0.5849	0.0863
	4.25	42.55	53.19	100			
Females	---	27	31	58	2.5344	0.5022	0.0659
	---	46.55	53.44	100			

TABLE V: 6. Age composition of speckled trout in Big Bear Cave Pond for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	I^+	II^+	III^+	IV^+	V^+	N	Mean	Std. Dev.	S.E.
Males and Females	2	77	32	9	2	122	2.4426	0.7251	0.0656
	1.63	63.11	26.22	7.37	1.63	100			
Males	1	30	16	6	1	54	2.5555	0.4143	0.0563
	1.85	55.55	29.62	11.11	1.85	100			
Females	1	47	16	3	1	68	2.3529	0.4232	0.0513
	1.47	69.11	23.52	4.41	1.47	100			

TABLE V: 7. Age composition of speckled trout in Indian Bay Big Pond for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	II+	III+	IV+	V+	VI+	N	Mean	Std. Dev.	S.E.
Males and Females	6 6.00	61 61.00	24 24.00	8 8.00	1 1.00	100 100	3.3700	0.7590	0.0759
Males	4 6.89	33 56.89	14 24.13	6 10.34	1 1.72	58 100	3.4310	0.8371	0.1099
Females	2 4.76	28 66.66	10 23.80	2 4.76	--- ---	42 100	3.2857	0.6325	0.0975

TABLE V: 8. Age composition of sea-run speckled trout in Indian River for sexes combined and separated. Standard deviations and standard errors calculated from actual frequencies.

	III+	IV+	V+	VI+	N	Mean	Std. Dev.	S.E.
Males and Females	2 10.00	7 35.00	10 50.00	1 5.00	20 100	4.5000	0.7609	0.1701
Males	1 11.11	4 44.44	4 44.44	--- ---	9 100	4.3333	0.7079	0.2359
Females	1 9.09	3 27.27	6 54.54	1 9.09	11 100	4.6363	0.8093	0.2439

TABLE V: 9. Age composition of speckled trout in Gander River and Terra Nova Lake for sexes combined. Standard deviations and standard errors calculated from actual frequencies.

	I^+	II^+	III^+	IV^+	V^+	N	Mean	Std. Dev.	S.E.
Gander River	2 3.07	24 36.92	36 55.38	3 4.61	--- ---	65 100	2.6153	0.6281	0.0779
Terra Nova Lake	2 2.89	11 15.94	33 47.82	18 26.08	5 7.24	69 100	3.1884	0.8948	0.1077

TABLE V: 10. Age composition of prize speckled trout taken from the Indian Bay Ponds, for sexes combined. Standard deviation and standard error calculated from actual frequencies.

	V^+	VI^+	VII^+	$VIII^+$	N	Mean	Std. Dev.	S.E.
Males and Females	6 24.00	12 48.00	5 20.00	2 8.00	25 100	6.1200	0.8063	0.1612

FIGURE V: 1. Age composition of speckled trout taken at Indian River, Gander River, Berry Hill Pond, and Stephen's Pond.

FIGURE V: 2. Age composition of speckled trout taken at Angle Pond, Thomas' Pond, Big Bear Cave Pond, and Indian Bay Big Pond.

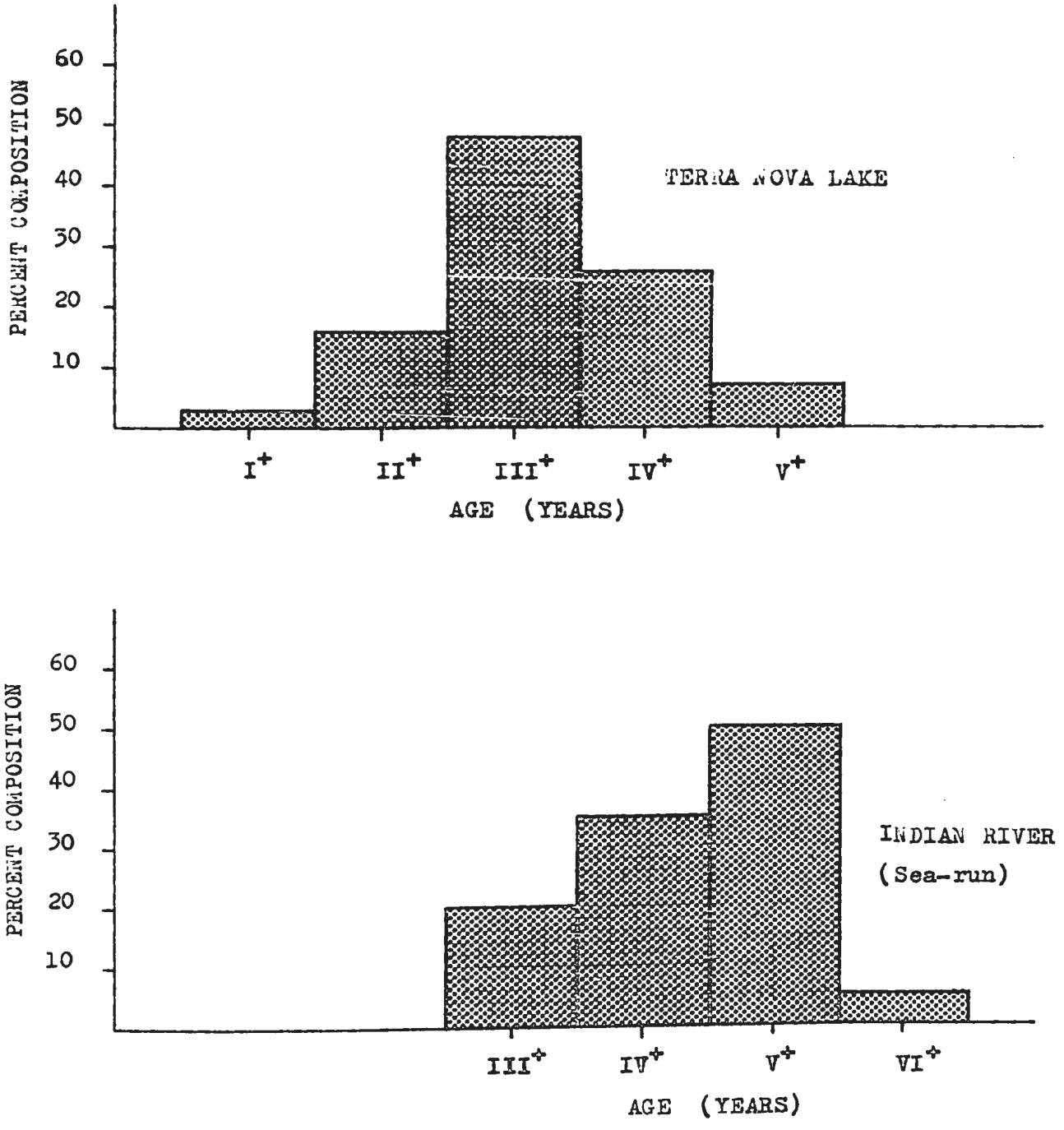


FIGURE V: 3. Age composition of speckled trout taken at Terra Nova Lake and Indian River.

(1932) figures a brook trout scale with five annuli. Hatcherymen, however, say it is not unusual for brook trout to reach eight years of age."

Rawson (1940), in studying speckled trout in the Maligne River system of Jasper National Park, found the maximum ages to be $\overline{VII}$ years and $\overline{VI}$ years for Maligne Lake and Beaver Lake respectively.

Doan (1948) found the maximum age attainable to be $\overline{VI}$ years for fish in the Nelson River region.

McFadden (1961) found that the life span for speckled trout in Lawrence Creek, Wisconsin, was also $\overline{VI}$ years.

Kendall and Fenderson (1963) in sampling five lakes on the Fish River, Maine, report $\overline{VI}$ years as the oldest age sampled, and remarked that few speckled trout over age V have been reported in the literature.

McCrimmon and Berst (1961) in a survey of an Ontario fish pond report very few speckled trout reached their fifth year and no trout older than this were in the pond.

Allen (1956) reports the maximum age in a Wyoming Beaver pond as $\overline{III}$ years.

Hazzard (1932) states that while studying some brooks and creeks in New York, the majority of legal size (6 inches) trout were found to be in their third and fourth years (II^+ and III^+), and individuals older than this were too rare to be used in the study.

From these literature reports it seems evident that the speckled trout does indeed have only a short life span. It would also seem apparent that the upper limit is governed by the size of the body of water. A general statement might be that longevity is related to increased spatial allotments.

Figure V: 4 shows a graphical presentation of mean ages for all the areas studied. As with the presentation of other means, the data are arranged in order of increased spatial magnitude of the areas. It is noticed that the larger bodies of water, namely Indian Bay Big Pond, Terra Nova Lake, and Indian River (Sea) produce longer living trout than do the smaller habitats. The Indian Bay Ponds "prize trout" show a much higher mean age but these are the result of selective angling, and only indicate the range of age in the area.

Figures V: 1-3 show that in all areas studied, the modal age classes were generally found to be either II^+ or III^+ years, the exceptions were the Indian River sea-trout with a modal class at V^+ years, and the Indian Bay Ponds "prize fish" with a modal class at VI^+ years.

Table V: 11 shows the difference in mean age between the sexes. Only in Big Bear Cave Pond is there a significant difference; the males have a mean age of 2.56 years, while the mean age for females is 2.35 years. The difference is significant at a probability of 0.01, suggesting differential mortality between males and females. McFadden (1961) reports differential mortality for trout in Lawrence Creek, Wisconsin, but here the females have a higher survival rate. He reports the sexes about equally represented in yearling fish but the proportion of females becomes greater in successively older age groups. Hoar (1957) suggests early attainment of sexual maturity by male fish may be associated with a shorter life span.

B. Mortality

Survival or mortality is usually measured using data from population estimation. However, fishery data may be used if (1) the population is stable from year to year, and (2) the various age classes are uniformly sampled by the sampling method used.

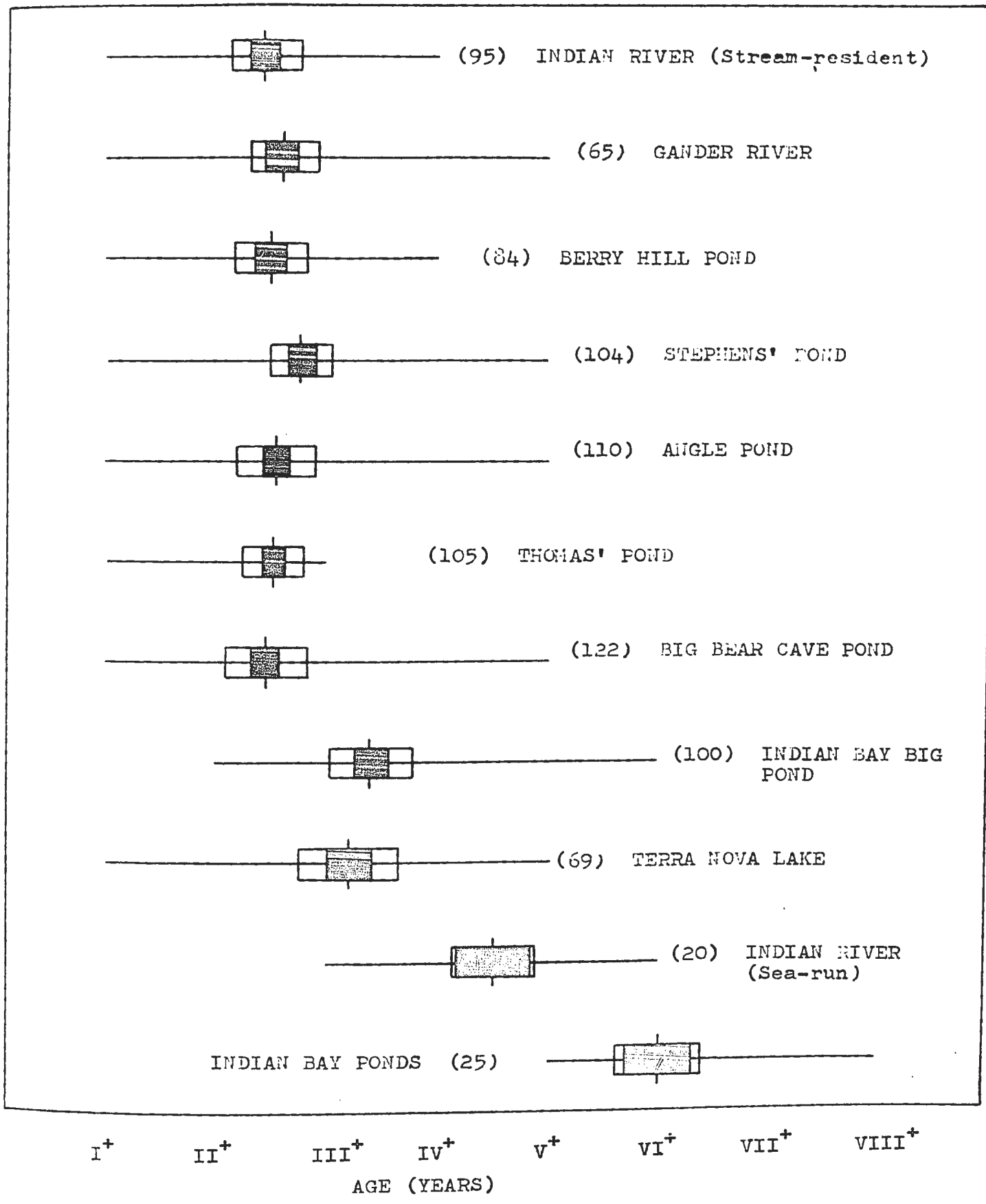


FIGURE V: 4. Graphical comparison of age data for speckled trout from various localities studied.

TABLE V: 11. Comparison of mean ages by sexes for speckled trout from all localities studied.

Locality	Sex	Mean Age	S.D.	S.E.	P. Value
Berry Hill Pond	male	2.4339(53)	0.6010	0.0817	0.16
	female	2.6451(31)	0.7119	0.1299	
Stephen's Pond	male	2.6585(41)	0.5698	0.0889	0.16
	female	2.8253(63)	0.5766	0.0726	
Angle Pond	male	2.5833(48)	0.8168	0.1178	0.77
	female	2.5483(62)	0.5903	0.0749	
Thomas' Pond	male	2.4893(47)	0.5849	0.0853	0.71
	female	2.5344(58)	0.5022	0.0659	
Big Bear Cave Pond	male	2.5555(54)	0.4143	0.0563	0.008**
	female	2.3529(68)	0.4232	0.0513	
Indian Bay Big Pond	male	3.4310(58)	0.8371	0.1099	0.32
	female	3.2857(42)	0.6325	0.0975	
Indian River (Stream-resident)	male	2.4406(59)	0.6205	0.0807	0.87
	female	2.4166(36)	0.7242	0.1207	
Indian River (Sea-run)	male	4.3333(9)	0.7079	0.2359	0.37
	female	4.6363(11)	0.8093	0.2439	

**significant at $\alpha = .01$.

The distribution of ages in a random sample of a fish population can be used to estimate the survival rate of the population during successive years of life. The survival rates of unexploited populations are of particular interest. The mortality rate determined from successive ages is then a measure of natural mortality in the population, and may be used as an estimate of natural mortality in considering total mortality of exploited populations of the same species.

From an age distribution the rate of total mortality can be calculated but it doesn't give any indication of the proportions caused by natural and fishing mortalities.

1. Natural Mortality

Cooper (1953) calculated fall egg production and estimated the number of fall fingerlings (yearlings) resulting from this egg production. He found a very low survival from egg to fingerling stage, averaging 3 to 4 per cent.

Shetter (1961) reports an average survival from egg to fall fingerling of 4.7 per cent in Hunt Creek, Michigan.

Records in the literature indicate that mortality among speckled trout eggs in the redds is relatively low as compared with mortality from eggs to fall fingerlings. Hazzard (1932) reported average egg mortalities in the redd as 20.2%. Brasch (1949) reported that in Wisconsin streams egg mortalities averaged 6.5 per cent. White (1930) reported egg-to-hatching mortality for some Prince Edward Island streams as 21 per cent. Finally, McFadden (1961) reported egg-to-sac-fry mortality as 8.5 per cent for Lawrence Creek, Wisconsin.

From these literature reports of low mortality among trout eggs in redds, it is concluded that much of the egg-to-fingerling mortality occurs after the fry emerge from the redds.

Whether the fry-to-fingerling (yearling) mortality is uniform over the period or whether it is for the most part confined to a shorter period within this interval is not certain. However, Smith (1947) concluded that "the highest mortality rate in the life cycle of trout seems to come in the fry stage, soon after emerging from the gravel." Satta (1962) reports highest mortality is during the period from hatching (March) to the end of June for fry in the Pigeon River, Michigan.

McFadden (1961) reports that after the first year of life, natural mortality of speckled trout continues, but at a lesser rate.

2. Angling Mortality

Angling mortality depends on a number of factors; these may include: (1) angling intensity, (2) angler's proficiency, (3) legal size limit, (4) legal bag limit, (5) accessability to anglers, (6) growth rate of the individuals in the population, (7) the type of angling gear (such as would cause differential mortality for fish size) and (8) the most widely overlooked factor, the catchability of the species concerned.

The present legal limit in the Province of 6 inches (15.24 cm.) barely protects the speckled trout through its first year of life, and the vast majority of the two year olds are fair game. However, in slower growing populations, such as would be found in brooks, gullies, and beaver ponds, the legal limit may protect trout up to four years of age.

Cooper (1953) reports that under a 7-inch limit for Pigeon River, Michigan, some of the fish in their second year (I^+) reach the limit, but fish

in their third year (II^{+}) bear the brunt of the angling mortality. He suggests that a high proportion of the annual total mortality in this age group is accounted for by the legal catch.

Shetter and Leonard (1942) reported that the anglers' catch in Hunt Creek, Michigan, in 1940, was 50 per cent of the standing crop of legal sized speckled trout (7 inches).

Rupp (1955) reports that age groups I, II, and III bear the brunt of angling mortality in Sunkhaze Stream, Maine, under a six-inch legal limit. In 1949, age IV fish comprised only 1.0 per cent, in 1951 age IV and V comprised 6.3 per cent, and in 1952 ages IV, V, and VI totalled 6.3 per cent of the catch.

Kendall and Fenderson (1963) report that in Fish River Lakes in Maine, age groups I-IV comprise the angling catch under a six-inch limit. They suggest that in lakes ages I and II are not fully vulnerable to the fishery even though many may have reached the legal limit. They suggest differential distribution in the lake and/or angler selectivity of older fish because of the type of gear used. This is supported by the fact that few sub-limit fish were reported taken by anglers.

3. Total Mortality

Total mortality is the sum of both natural and angling mortalities.

Shetter and Leonard (1942) report that in Hunt Creek, Michigan, the total mortalities between years were as follows: (1) 0 - I, 35 per cent; (2) I - II, 36 per cent; and (3) II - III, 86 per cent.

In an Ontario farm pond, McCrimmon and Berst (1961) report an annual total mortality rate of about 60 per cent for age 0 - I and age II - III;

and 94 per cent from age II - III. They suggest the fishing mortality among trout over 7 inches, estimated to be 71.4 per cent, contributed substantially to total mortality.

Rupp (1955) gives the following total annual mortality rates for Sunkhaze Stream: (1) from age II - III, 52 per cent; (2) from age III - IV, 78 per cent; (3) from age IV - V, 84 per cent; and (4) from age V - VI, 88 per cent.

The total annual mortality rate may be estimated by substituting age composition data in the Jackson formula (Ricker, 1948).

Jackson's (1939) well-known formula,

$$\text{Survival (s)} = \frac{x_2 + x_3 + x_4 + \ldots x_n}{x_1 + x_2 + x_3 + \ldots x_{n-1}},$$ may be used

to estimate the average annual survival of all age groups; average total annual mortality is the compliment of survival.

Needham, Moffett, and Slater (1945), Shuck (1945), and Needham (1949) point out that the annual total mortality of speckled trout populations is high, averaging better than 50 per cent.

Rupp (1955) found for all ages above I, the annual total mortality was 62.2 per cent, and Kendall and Fenderson (1963) found that for five Fish River lakes in Maine, the average annual total mortality from ages III to VI was 64 per cent.

Table V: 12 shows the survival and mortality rates between age groups for all localities studied. Generally, the survival rate decreases between older age groups.

Table V: 13 shows total annual mortality and survival rates for all localities with sexes combined. It can be seen that the annual survival rate

TABLE V: 12. Survival and Mortality rates calculated from age compositions for speckled trout from various localities in Newfoundland.

Locality	Survival (§) and Mortality (1-§) Rates		
	Age Classes	Survival Rate	Mortality Rate
Indian River (Stream-resident)	$II^+ - III^+$	0.686	0.314
	$III^+ - IV^+$	0.143	0.857
Gander River	$III^+ - IV^+$	0.083	0.917
Berry Hill Pond	$II^+ - III^+$	0.711	0.289
	$III^+ - IV^+$	0.188	0.812
Stephen's Pond	$III^+ - IV^+$	0.042	0.958
	$IV^+ - V^+$	0.333	0.667
Angle Pond	$III^+ - IV^+$	0.010	0.930
	$IV^+ - V^+$	0.250	0.750
Big Bear Cave Pond	$II^+ - III^+$	0.416	0.584
	$III^+ - IV^+$	0.281	0.719
	$IV^+ - V^+$	0.222	0.778
Indian Bay Big Pond	$III^+ - IV^+$	0.393	0.607
	$IV^+ - V^+$	0.333	0.667
	$V^+ - VI^+$	0.125	0.875
Terra Nova Lake	$III^+ - IV^+$	0.545	0.455
	$IV^+ - V^+$	0.278	0.722
Indian River (Sea-run)	$V^+ - VI^+$	0.100	0.900

TABLE V: 13. Average total annual survival and mortality for speckled trout taken from various localities in Newfoundland

Locality	Ages	Number of Fish	Average Annual Survival(s)	Average Annual Mortality(m)
Indian River (Stream)	II - IV	91	.47	.53
Berry Hill Pond	II - IV	83	.49	.51
Gander River	III - IV	39	.08	.92
Stephen's Pond	III - V	75	.05	.95
Angle Pond	III - V	62	.08	.92
Big Bear Cave Pond	II - V	120	.36	.64
Indian Bay Big Pond	III - VI	94	.35	.65
Terra Nova Lake	III - V	56	.45	.55
Indian River (Sea)	V - VI	11	.10	.90

ranges from a low of 5 per cent to a high of 65 per cent. The significance of this difference will be discussed in more depth when the age compositions are considered in more detail.

Table V: 14 shows the differential mortality and survival rates between the sexes. There does not seem to be any consistent difference, any apparent difference for any one area is probably due to small sample size.

TABLE V: 14. Average total annual survival and mortality for speckled trout compared by sexes.

Locality	Sex	Ages	Number of Fish	Average Annual Survival(s)	Average Annual Mortality (m)
Indian River (Stream)	male	II - IV	57	.47	.53
	female	II - IV	34	.45	.55
Berry Hill Pond	male	II - IV	52	.44	.56
	female	II -IV	31	.59	.41
Stephen's Pond	male	III - V	27	.04	.96
	female	III - V	48	.06	.94
Angle Pond	male	III - V	27	.15	.85
	female	III - IV	35	.03	.97
Big Bear Cave Pond	male	II - V	53	.44	.56
	female	II - V	67	.30	.70
Indian Bay Big Pond	male	III - VI	54	.40	.60
	female	III - V	40	.32	.68

C. Analysis of Age Compositions

With a background knowledge of some of the factors which can influence an age composition, it is possible to consider in detail each of the present age compositions separately.

1. Indian River (Twenty-three Mile Brook)

This population has a life span of IV^+ years and a modal class at II^+ years. The mean age is 2.43 years and there is an apparent total annual mortality rate 53 per cent. There is no significant difference in the mean age of males and females, and little evidence of differential mortality.

The 53 per cent rate of loss from age II^+ to IV^+ may not be entirely due to mortality, but probably due largely to migration. Angling is either light or non-existing. Twenty-three Mile Brook apparently acts as a breeder stream for Indian River sea trout, for as we shall see later, meristic counts are remarkably similar to the sea-run population. Generally, breeder streams are small, cool, tributaries near the headwaters of a river system, and usually show a higher standing crop or biomass per unit area than does the main river. Hoover (1939) reports that in four New Hampshire breeder streams, the number of trout per acre ranged from 356 to 2600, with an average near 1000. Fisheries biologist C. Sturge (pers comm.) indicated to the author that very few speckled trout were taken in Indian River proper while electrofishing; however, the greatest density in the area was for Twenty-three Mile Brook.

Hoover (1939) also reported a slow growth rate in breeder streams and reported a maximum age of IV years, with only a few individuals reaching the legal limit of six inches. This corresponds very closely with conditions in Twenty-three Mile Brook.

White (1940) reports that in Moser River, Nova Scotia, seaward trout smolt migration occurs at ages II and III, with the bulk composed of II year

olds. Smith and Saunders (1958) report in Prince Edward Island, migrating smolts are I, II, and III year olds, with mostly II year olds. Bigelow et al (1963) reports that in Newfoundland waters, the majority go to sea at III years of age. In the absence of angling in Twenty-three Mile Brook, seaward migration would then account for a high percentage of the loss between age II^+ and IV^+.

2. Gander River (South-West Branch)

The trout here have a life span of IV^+ years and a modal class at III^+ years. The mean age is 2.61 years and the annual total mortality rate is 92 per cent. The high mortality indicates either a short life span in the river habitat, or migration to the main river or to the sea, or possibly both. Angling mortality is not thought to be significant because of the inaccessability of the area.

3. Berry Hill Pond

The trout of this small pond apparently only live to an age of IV^+ years, and have a modal class at II^+ years. The mean age was found to be 2.51 years and the annual total mortality rate was only 51 per cent. There was no difference in mean age between the sexes and no evidence of differential mortality.

The low annual mortality is undoubtedly due to low angling intensity, as the inhabitants of the nearby settlement (Burin Bay Arm) informed the author that the small size of the trout was the reason for an almost complete lack of angling. The short life span is again thought to be related to limited spatial allotment.

4. Stephen's Pond

This population reaches a maximum age of V^+ years and has a modal

class at III^+ years. The mean age is 2.76 years and the annual total mortality rate is very high at 95 per cent. There is no difference in mean age between the sexes and no evidence of differential mortality. Angling mortality is blamed for a significant portion of total mortality as this pond is a favourite of anglers, having been so for many years. It would seem that spawning is very successful in this pond and that the I year olds and a good percentage of the II year olds are not vulnerable to anglers, in order to explain the good fishing yield each year. The increase in life span to V^+ years is thought to be associated with an increase in water surface area.

5. Angle Pond

This pond has trout attaining a maximum age of V^+ years with a modal age class at III^+. The mean age is 2.56 years and the annual total mortality is high at 92 per cent. There is no difference in mean age between males and females and no evidence of differential mortality. The low survival rate is blamed on angling mortality in this instance alsc, as the pond is located at Mahers, a popular summer resort. The pond is accessable by both road and railway and anglers are known to frequent this area heavily. The increase in life span to V^+ years is again associated with an increase in spatial allotment.

6. Thomas' Pond

The trout in this pond have an apparent life span of only III^+ years with a modal age class at III^+. The mean age was found to be 2.51 years. However, it would appear that incomplete sampling did not include older age groups if they were present, as the distribution is negatively skewed to the left. The reason was probably the scarcity of older age groups in the area

sampled as this area was also the prime angling area, and angling intensity was extreme. Therefore, no mortality estimates could be made for this sample. There was no difference in the mean age of males and females.

7. Big Bear Cave Pond

This area has trout attaining a maximum age of V^+ years, at least according to sampling. The mean age was found to be only 2.44 years and this may be low in the light of sampling procedures previously discussed. The modal class was found to be II^+ years and the annual total mortality rate was 64 per cent. Males have a significantly higher mean age than females at a probability of 0.01, and differential survival would seem to favor males. Considering the size of the body of water and lower than usual angling intensity, it would seem that V^+ years is a little low as an estimate of life span especially since trout of $VIII^+$ years have been taken in this water system. The lower exposure to angling intensity undoubtedly is a factor in the relatively high survival rate.

8. Indian Bay Big Pond

The highest age sampled in this pond was VI^+ years (again not necessarily the maximum age attainable), the increase in life span probably being due to increased size of the water area. The mean age was 3.37 years and the modal class was at III^+ years. The annual total mortality was moderate at 65 per cent. Males and females did not differ significantly in mean age, and differential mortality is not apparent. The relatively low annual total mortality rate is certainly linked with inaccessability and low angling mortality.

9. Terra Nova Lake

This lake shows V^+ years as the life span of its trout. The mean age

is 3.19 years and the modal class is at III^+ years. The total annual mortality rate is a low 55 per cent. The low mortality is probably due to the large size of the lake and the relatively decreased availability to anglers.

10. Indian River (Sea trout)

The maximum age of the sea trout was VI^+ years, with a mean age of 4.50 years. The modal class was at V^+ years, and the annual total mortality was high at 90 per cent. There was no difference in the mean age of males and females. The low annual survival of sea trout is not unusual (Menzies, 1936). Besides natural mortality, predators in the sea and anglers take a great percentage.

11. Indian Bay Ponds (Prize-trout)

As was previously mentioned, a high of $VIII^+$ years was recorded (2 trout), with a mean age of 6.12 years. The modal class of these prize trout was VI^+ years.

The scarcity of trout of this calibre, in itself, indicates both the life span and mortality of most of our speckled trout.

VI. GROWTH

A. General Considerations

1. Definition and Description of Piscine Growth

Essential in any study of the life history and biology of a fish is some knowledge of the nature and rate of its growth.

Growth can be defined simply as increase in size. It is the net result of the differences of the animal's anabolic and catabolic rate. Since growth is manifested as an increase in size, it is perhaps best measured as weight or volume of the animal. However, most piscine growth studies have been made from observations on length measurements. Length has been found to be a satisfactory basis for measurement of growth since it has been shown that the relationship of length to weight remains fairly constant for a species throughout its life.

Fishes have a remarkable growth pattern in that they have the ability of sustained though diminishing growth throughout their entire lives if suitable biotic and physical environmental agencies are maintained. This ability is termed indeterminate growth. Thus it is possible that members of the same species may assume a variety of sizes at the same age.

A suggested explanation is that since fish are living in a fluid medium which supports them mechanically, they are able to grow throughout their lives because there are more biotic than mechanical limits imposed on their maximum sizes (Lagler et al, 1962).

2. The Effect of Gear Selectivity on Growth Calculations

The length or weight data used for growth studies are obtained in

one of two ways: (1) by taking repeated measurements on the same fish or (2) by taking measurements on samples from the population. The first of the two methods is applicable only to growth determination for individual fish and is not a population technique. Therefore, for growth determination for the population as a whole, the latter method is used.

The data or measurements are taken from a sample which has been obtained by some type of sampling gear. Because of inherent selectivity by most gears, any discussion of growth rates of fishes should consider the errors related to this selectivity. For instance, the most active members of the population may be more vulnerable to passive gears while they may be better able to escape active gears. We then have to ask whether the sample is representative of the population as a whole.

Cooper (1953) has shown that angling is selective for faster growing speckled trout of each age group, regardless of size. The selective effect of angling has also been noted for arctic grayling (Gustafson, 1949).

Ricker (1958) suggests that if only one sampling gear or method is used, it is unlikely to be representative for all ages. Should the gear be more efficient for intermediate sized fish, then it will select more of the larger members of the younger age groups and similarly the smaller members of the older age groups. If this fact is not taken into consideration, Ricker suggests the growth rate obtained will be invariably smaller than the actual. The same would be true if the selectivity is for the smallest or for the largest. The best way to avoid this bias is to use a combination of sampling gears all of which may have some particular inherent selectivity for size to some extent, but will select different size ranges.

As was previously mentioned, selective mortality, especially if man is involved, is probably directed towards the faster growing members of any age group. For this reason any heavily fished trout stream or pond will yield a sample of gill-netted fish which will invariably show a growth rate slower than the actual.

Ricker also suggests that natural selection could conceivably be more effective on either the larger or smaller fish. Faster growers may mature earlier and die earlier than smaller, slower growing individuals, which on the other hand, may be more susceptible to predators.

Since we have thus seen that selectivity is a problem, it is felt that the bias has been reduced as much as possible through the use of more than one sampling technique. In most instances, at least two sampling procedures were utilized, with gill nets, seines, and angling being employed.

3. Factors Influencing the Growth of Trout

It has long been known that the growth rate of trout was different in different waters, and there has been widespread speculation concerning the factors responsible for these differences.

Generally, we can state that the factors influencing the growth rates of fishes may be of three types: (1) genetic, (2) physiological, and (3) environmental.

Higgins (1929); Hayford and Embody (1930); Davis (1934); and Dinsmore (1934); and numerous recent authors have shown that the growth rate of speckled trout can be increased by selective breeding. Dahl (1918) suggests that small, slowly growing trout are derived from smaller ova than those growing more rapidly, and suggests egg size varies with genetic strains

and with it varies the initial size at hatching. In nature the presence of genetic variations in growth potential in populations of the same species is usually masked by environmental factors, but as Brown (1946) points out, the advantages may be lifelong.

Minot (1890) was the first to point out that for fish the specific growth rate is highest in early life and shows decreasing acceleration as the fish increases in age and size. He suggests this negative acceleration depends on age and not size, and may be partly a physiological effect of tissue aging.

Perhaps the most important factors concerned with the growth of fish are environmental, both physico-chemical and biotic. The chief physico-chemical factors are temperature, illumination, concentration of gases and dissolved salts, and rate of water flow; while the most important biotic factors are food supply (both quality and quantity), and inter- and intraspecific piscine relationships.

Experimental work with salmonid fry has shown the importance of light (Tryon, 1942) and of rate of water flow (Washbourn, 1936).

There is ample evidence in the literature of the importance of temperature on the growth of trout. Titcomb, 1920; Leach, 1923; Belding, 1928; and Davis, 1929 all drew attention to differences in growth of trout in hatcheries supplied with water of different temperatures. Hubbs, Greeley, and Tarzwell, (1932) observe that "the coldest spring water . . . is much less conducive to growth than considerably warmer water." Hazzard (1932) has attributed the slow growth of speckled trout in certain New York State streams to low water temperatures. Cooper (1953) observed a marked increase in the condition and growth rate in several Michigan streams with

rising temperatures in late spring and early summer.

Job (1955) found that the active respiration of speckled trout larger than a certain size is limited by the available oxygen at temperatures above 15°C. Fry (1957) has suggested that it may be the respiratory system which limits growth, and Swift (1961) suggested that above 12°C the incapability of the brown trout's respiratory system to meet respiratory needs caused a decrease in growth rate.

Southern (1932, 1935) first suggested that rapid growth was correlated with hard or alkaline water. Went and Frost (1942) and McFadden (1961) have subsequently confirmed this for brown trout in Europe and North America respectively. Sherrer (1963) has also found the relationships to hold for speckled trout.

Dahl (1918) suggested that the food supply and the degree of crowding were important in determining the growth rate of brown trout, and Cooper (1959) suggested the same reasons for variation in growth of speckled trout.

Brown (1946) has further shown that the size hierarchy at hatching (Dahl, 1918) is maintained throughout life and the size relative to others is the most important factor influencing the growth rate.

4. Growth Compensation

In piscine growth studies based on back calculation from scale measurements, many investigators dealing with various species have found that those members of an age group which were initially slow growing grew faster in later years than their initially faster growing contempories of that same age group. This so called "law of growth compensation" was first described by Gilbert (1914) in relation to the sockeye salmon (Oncorhynchus nerka).

Cooper (1953) has demonstrated that speckled trout in the Pigeon River, Michigan, also show growth compensation. Using calculated lengths from two and three year old fish he showed that although growth increments of different sized fish are similar, the relative growth of the fish that were the slow growing yearlings is greater than that of those which were the larger yearlings. However, Cooper states that this growth compensation is not sufficient to overcome the original difference in growth shown during the first year, and the larger yearlings maintain their dominance in size throughout the first three years at least and it was not known if the phenomenon extended beyond three years as older age groups were not available.

The fact that the growth compensation is insufficient to offset initial slow growth is important from the management viewpoint. Under a low minimum size limit the fish with the potential to become prize specimens are harvested first.

5. Periodicity of Growth

Although no attempt was made in this investigation to consider the periodicity of growth due to the inability to sample the year round, it is felt that a consideration of information in the literature is imperative to the overall appreciation of the grosser aspects of yearly growth.

The first record of significance dealing with periodicity of growth in speckled trout is by Cooper (1953) who gathered data from three Michigan streams. In all three streams the growth rate increased rapidly during the last week in April or first week in May, remaining rapid during May and June, and slowed up considerably during July, August, September

and October. Growth for all intents and purposes ceased from November to March.

Fry (1951) in a consideration of some environmental relations of the speckled trout listed temperature as one of the most decisive factors in determining its success. Baldwin (1951) reports optimum growth as taking place at 57°F. and Davis (1946) states that in hatcheries optimum temperatures for growth range from 55° to 60°F.

These temperature data on optima for growth agree with Cooper's field observations. A change in maximum temperature from 40° - 50°F. during April, to 50° - 60°F. during May and June, is accompanied by a marked increase in growth.

McFadden (1961) states that in Lawrence Creek, Wisconsin, speckled trout of age groups I and older have completed their annual growth by September, however, young-of-the-year (age group 0) continued to grow into November, with a considerable length increment being added after September. Growth in length was found to be nearly rectilinear from February through August for young-of-the-year, then declined slightly through mid-November. Little or no growth was evident from mid-November until sometime between late January and early March. For fish of age group I and older, growth was approximately rectilinear from March through mid-August. Then no appreciable growth occurred until sometime between late January and early March.

The only information available on the growth periodicity of speckled trout in Newfoundland is from casual observation of the deposition of circuli on the scale edge. It would appear that growth begins in late April or early May and ends by September.

The marked difference in growth pattern between wild and hatchery strains of speckled trout may help to elucidate some of the environmental factors involved in growth periodicity. Generally, hatchery trout show greater growth than wild trout for the entire year, mainly because their growth starts earlier in the season due to favorable temperatures and because they grow at a relatively fast, though declining rate, for a greater part of the year. The almost complete lack of seasonal decline during the fall and winter is probably due to the maintenance of sufficiently high temperatures suitable for active growth.

As we have seen wild populations in cold climates are able to grow at a maximum rate for only short periods when the optimum temperature is available. Generally growth per se. is possible for about six months and the bulk of this is accomplished in perhaps two months. During a short period of optimum conditions (temperature and food) both wild and hatchery trout grow at comparable rates. In late summer a decline in food usually is responsible for a growth decline, even though temperatures may be favorable (Cooper and Benson, 1951 and Ellis and Gowing, 1957). In winter temperature is usually the limiting factor since it has been shown that even if food is available it cannot be efficiently utilized (Leonard, 1942). We can therefore simply say that the larger size of hatchery trout at any given period is the result of growing at a higher average rate for a longer period. This fact becomes quite significant when we consider the growth of the species in more northern climes (such as in Newfoundland) where the duration of this period of optimum growth may vary widely from more southern latitudes, and where the location of this optimum period within the general growth period may also differ. Superimpose upon this problem the problem of

regional variations and that of other environmental factors and the result is a complexity which is not easily dispensed with during growth considerations.

6. The Mathematical Expression of Growth

The simplest growth curve is a time diagram which defines dimensions at specified times. The typical curve is the S-shaped or sigmoid curve. As was previously mentioned, the dimensions most often used in fishery biology are those of length and weight. The curve that fits the variables of time and dimensions may be closely simulated by mathematical models of varying degrees of complexity.

The simplest of these growth curves, the sigmoid curve, gives the velocity of change in dimension (length or weight) or rate of growth. However, it does not describe the exact mode of growth of a species, but is the simplest mathematical curve which fits the two variables, and for determination of average growth rates it has been found to be adequate.

Because fish have indeterminate growth, they approach their ultimate or limiting growth very slowly, as can be seen in the sigmoid curve. From this curve we can also see that growth is at first slow, then is positively accelerated until the inflection point is reached. Beyond this point growth is slower or negatively accelerated.

The exact manner in which fish grow is much more complex than that shown by a simple time series. Growth is the result of metabolic rates which may be either accelerated or retarded by changes in both physico-chemical and biotic environmental factors. Therefore variations in growth rate occur, and although they are biologically important, they do not seriously impair the results obtained from average growth rate formulae

providing the mean dimensions (length and weight) of the age groups are unbiased estimates for the population.

Two general approaches have been made describing growth curves mathematically. For sigmoid curves if the inflection point comes early in life, the logistic curve usually gives a straight line fit. However, as already mentioned, this type of curve gives little insight into the mechanics of growth.

The second approach has been to divide the sigmoid curve at the inflection point and fit the two halves with separate curves.

Generally in fisheries biology we are not concerned with the curve below the inflection point as it represents larval or early fingerling growth (Hayes, 1949 and Allen, 1950, 1951).

Brody (1927, 1945) in describing the portion above the inflection point with decreasing slope, used:

$$l_t = B - Ce^{-kt} \qquad (1)$$

where l is length and t is age; B and C are parameters of length; and k is a constant determining the rate of change in length increment.

This form has been found to be applicable for growth studies of older fish, sometimes from age I onward, but more commonly starting at a greater age.

Brody's relationship can readily be changed to the form used by von Bertalanffy (1934, 1938):

$$l_t = l_\infty (1 - e^{-k(t-to)} \qquad (2)$$

where l_∞ is the value which l assumes as age increases indefinitely, and is called the asymptotic length of the fish.

The Bertalanffy curve is a curve of the decaying exponential type and is perhaps the best attempt at providing a physiological basis for a growth equation. He regards the rate of growth of an organism as being dependent upon both processes of anabolism and catabolism.

Yet another form has been obtained from equation (1) by duplicating equation (2) using t + 1 for t, and subtracting the resulting equation from (2). Putting $k = 1^{-k}$, this relationship is:

$$l_{t+1} = l_\infty(1 - k) + k l_t \quad (3)$$

This expression was developed empirically by Ford (1933) and by Walford (1946), and is commonly called the "Walford line".

Walford's method of plotting size at age t against size at age t + 1 transforms a generally depressed curve into a straight line. This line has a slope of less than 1 and intersects the 45° line. Two constants, characteristic of this transformation, may be derived. These constants are: k, which is the slope of the transformed line, and l_∞, which describes the asymptotic length, or maximum size attained by the fish.

An effort was made to fit the actual length data of this study to the Walford transformation, however, success was limited as the points were too erratic for good straight line fits. It was found that the two terminal values were the most erratic probably due to the fact, as Ricker (1958) suggests, the two terminal values are more susceptible to sampling error and are used only once, whereas the intermediate values are used twice.

The age-length data were then transformed to the log regression form and the calculated lengths fitted to the Walford transformation, and a satisfactory linear fit resulted from the smoothed logistic values.

Figure VI. 1 shows examples of two such Walford transformations, for Terra Nova Lake and Thomas' Pond.

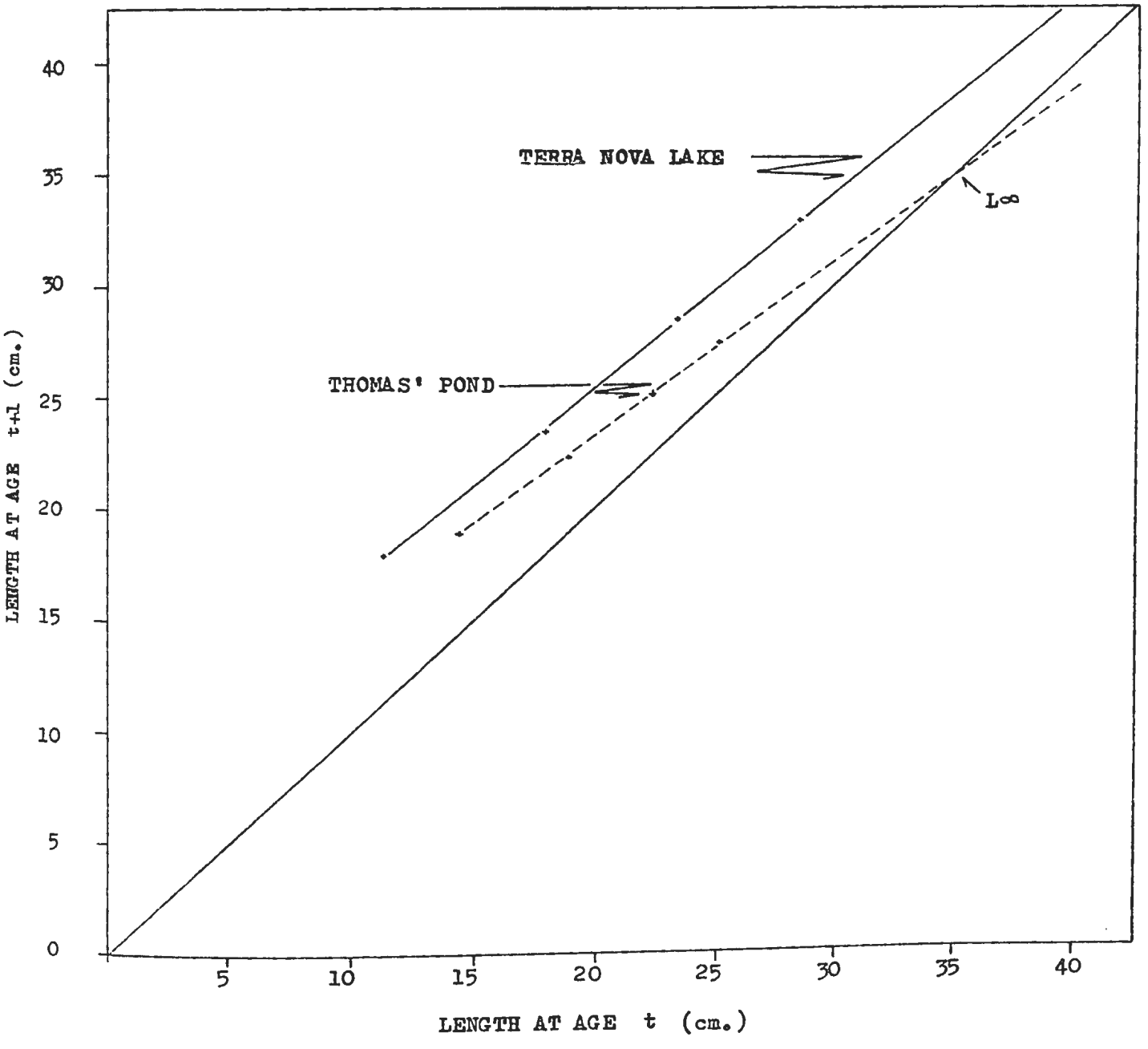


FIGURE VI. 1. Walford graphs, of length in cm. at age t + 1 against length at age t, for Thomas' Pond and Terra Nova Lake.

The l_∞ values may be simply read off the graph or calculated from equation (3). However, for better fits the trial value is read off the graph and used in an expression derived from equation (3) by taking logarithms, giving:

$$\log_e (l_\infty - lt) = \log_e l_\infty + kto - kt \quad (4)$$

Thus a graph of $\log_e (l_\infty - lt)$ against t should be straight, and the straightness is sensitive to changes in l_∞. A few trial plots yields the value of l_∞ which gives the straightest line (Ricker, 1958).

Table VI. 1 shows the growth characteristics of the Walford transformations for the speckled trout in the areas studied. (W_∞ is calculated from L_∞ using the length-weight relationship, assuming the relationship holds throughout old age).

There are two sources of error to be considered. The most common error is probably selection of larger fish of each year class, which would increase the value of l_∞, and secondly reading scales of old fish consistently too low results in a lower l_∞.

Cooper (1961) has also used the Walford approach for speckled trout, however he suggests the values of l_∞ may be unrealistic. For instance he found that one value of 21.8 inches was less than the known length attained by a particular group of trout in actual performance, and a value of 37.7 inches was obtained which corresponds to a weight of 29 pounds, which has never been approached by the species anywhere. He questions the logic of calculation of asymptotic lengths by extrapolation from segments of a growth curve even when the segment of the curve extends over a large portion of the predicted ultimate size of the fish.

TABLE VI. 1. Growth characteristics of the Walford transformations of eight groups of speckled trout from Newfoundland localities.

Locality	k	L_∞		W_∞	
		cm.	in.	gm.	lb.
Indian River (stream-resident)	.788	30.52	12.02	235.9	0.52
Gander River	.755	31.18	12.28	344.5	0.76
Berry Hill Pond	.780	32.95	12.97	408.4	0.90
Stephen's Pond	.787	35.77	14.08	527.9	1.16
Angle Pond	.839	52.17	20.54	2167	4.78
Thomas' Pond	.784	35.69	14.05	595.8	1.31
Big Bear Cave Pond	.847	55.75	21.95	1823	4.02
Indian Bay Big Pond	.874	65.18	25.66	2934	6.47
Terra Nova Lake	.871	61.86	24.35	2637	5.81

Larkin, Terpenning, and Parker (1956) suggest that although genetic factors set the potential of growth, it may not be so conveniently summarized mathematically. They suggest there may not be a sharply defined ultimate size. Moreover, many species (including salmonids) change their ecological niche as they grow larger, and perhaps revising the ultimate

size to which their growth is related. Finally, speckled trout are relatively short lived, and growth studies based on scale reading provide few annuli as reference points for estimation of future growth.

Some of the ultimate sizes shown in Table VI. 1 may appear at first glance to be rather high, however, it is felt that they represent the limiting size to a fair degree of accuracy. The L_∞ value of 25.66 inches (6.47 pounds) for Indian Bay Big Pond is known to be approached; as was mentioned previously, the author has information that trout of approximately 6 pounds have been taken in this area. Angle Pond, which for many years has been recognized as a producer of prize trout, yielded a L_∞ value of 20.54 inches (4.78 pounds). The rate of growth indicates a genetic or physiological potential to approach this limit; however, the influence of high angling pressure may have reduced the probability of a given trout reaching this size. The other area yielding a seemingly high value of L_∞ was Terra Nova Lake with 24.35 inches or 5.81 pounds. Since the author is not familiar with this locality or the angling success, it can only be surmised that the value is realistic.

The values of L_∞ for the other areas seem realistic as the author is familiar with the localities and the overall angling picture.

B. Growth in Length

1. Absolute Growth

Absolute growth is the average total size at each age. It is usually presented as the regression of length on age, or average length for each age group. As was mentioned previously, the absolute growth curve is generally sigmoid.

While it is recognized that plotting the length of fishes as a simple time series provides little insight into the mechanism of growth, it was felt that this simple approach would be effective for simple comparison of growth between localities and habitats.

(a) Empirical Age - Length Relationship

Estimation of annual growth was obtained by calculating the mean length of each age group from the sample length-age distribution. The calculations are based on the assumption that the mean length of each age group is the mode. No weighted-mean corrections were made for grouping and obviously the assumption may not hold true in all cases, especially for terminal values where numbers of fish are small and more subject to sampling error.

Table VI. 2(a-j) shows the length distribution of age groups, and the corresponding mean lengths for age groups. The overlap in length frequencies between age groups is noted and implies, as already mentioned, that the nature of piscine growth is such that members of the same age group may assume a variety of sizes within certain limits.

The empirical age-length data for both sexes separated and combined are given in Table 1 Appendix II, and includes data from all localities studied.

The age-length data for sexes combined are presented graphically in Figures VI. 2(a-b). The growth pattern of the species in Newfoundland waters parallels the almost universal situation found elsewhere in its range, or as Scott and Crossman (1964) suggest, "Growth data . . . exemplifies the direct relationship of growth rate with habitat area." The growth data from this study, like that of Scott and Crossman (1964), indicate "a steady increase

TABLE VI: 2a. Length Distribution of Age Groups for Terra Nova Lake, (Sexes combined).

Fork Length (cms.)	Age Groups					Total
	I^+	II^+	III^+	IV^+	V^+	
9.55 - 11.55	1	---	---	---	---	1
11.55 - 13.55	1	---	---	---	---	1
13.55 - 15.55	---	2	---	---	---	2
15.55 - 17.55	---	4	---	---	---	4
17.55 - 19.55	---	4	3	---	---	7
19.55 - 21.55	---	1	7	---	---	8
21.55 - 23.55	---	---	11	---	---	11
23.55 - 25.55	---	---	8	1	---	9
25.55 - 27.55	---	---	4	8	---	12
27.55 - 29.55	---	---	---	4	---	4
29.55 - 31.55	---	---	---	2	---	2
31.55 - 33.55	---	---	---	3	---	3
33.55 - 35.55	---	---	---	---	4	4
35.55 - 37.55	---	---	---	---	---	---
37.55 - 39.55	---	---	---	---	1	1
Total number of fish	2	11	33	18	5	69
Mean Length	11.75	17.34	22.64	28.32	34.84	23.72

TABLE VI: 2b. Length Distribution of Age Groups for Thomas' Pond, (Sexes combined).

Fork Length (cm.)	Age Groups			Total
	I^+	II^+	III^+	
13.55 - 15.55	2	---	---	2
15.55 - 17.55	---	3	---	3
17.55 - 19.55	---	22	---	22
19.55 - 21.55	---	19	26	45
21.55 - 23.55	---	3	21	24
23.55 - 25.55	---	---	8	8
25.55 - 27.55	---	---	1	1
Total number of fish	2	47	56	105
Mean Length	14.20	19.47	22.07	20.72

TABLE VI: 2c. Length Distribution of Age Groups for Big Bear Cave Pond, (Sexes combined).

Fork Length (cms.)	Age Groups					Total
	I^+	II^+	III^+	IV^+	V^+	
9.55 - 11.55	---	---	---	---	---	---
11.55 - 13.55	---	---	---	---	---	---
13.55 - 15.55	2	8	---	---	---	10
15.55 - 17.55	---	44	---	---	---	44
17.55 - 19.55	---	22	3	---	---	25
19.55 - 21.55	---	3	1	---	---	4
21.55 - 23.55	---	---	6	---	---	6
23.55 - 25.55	---	---	3	---	---	3
25.55 - 27.55	---	---	11	---	---	11
27.55 - 29.55	---	---	6	1	---	7
29.55 - 31.55	---	---	2	1	---	3
31.55 - 33.55	---	---	---	6	---	6
33.55 - 35.55	---	---	---	1	1	2
35.55 - 37.55	---	---	---	---	1	1
Total number of fish	2	77	32	9	2	122
Mean Length	14.60	17.32	25.37	31.73	34.90	20.60

TABLE VI: 2d. Length Distributions of Age Groups for Indian River. (Stream resident fish). Sexes combined.

Fork Length (cms.)	Age Groups				Total
	I^+	II^+	III^+	IV^+	
5.55 - 7.55	1	---	---	---	1
7.55 - 9.55	3	---	---	---	3
9.55 - 11.55	---	6	---	---	6
11.55 - 13.55	---	35	---	---	35
13.55 - 15.55	---	10	15	---	25
15.55 - 17.55	---	---	10	---	10
17.55 - 19.55	---	---	10	1	11
19.55 - 21.55	---	---	---	---	---
21.55 - 23.55	---	---	---	4	4
Total number of fish	4	51	35	5	95
Mean Length	8.05	12.89	16.24	21.72	14.30

TABLE VI: 2e. Length Distribution of Age Groups for Indian River Sea Run fish. (Sexes combined).

Fork Length (cms.)	Age Groups 3^+	4^+	5^+	6^+	Total
23.55 - 25.55	1	---	---	---	1
25.55 - 27.55	1	1	---	---	2
27.55 - 29.55	---	2	---	---	2
29.55 - 31.55	---	4	---	---	4
31.55 - 33.55	---	---	8	---	8
33.55 - 35.55	---	---	1	---	1
35.55 - 37.55	---	---	1	---	1
37.55 - 39.55	---	---	---	---	---
39.55 - 41.55	---	---	---	---	---
41.55 - 43.55	---	---	---	---	---
43.55 - 45.55	---	---	---	1	1
Total number of fish	2	7	10	1	20
Mean Length	25.30	29.61	33.09	44.10	31.65

TABLE VI: 2f. Length distribution of age groups for Berry Hill Pond (sexes combined).

Fork Length (cm.)	Age Groups				Total
	I^+	II^+	III^+	IV^+	
9.55 - 11.55	1	---	---	---	1
11.55 - 13.55	---	6	---	---	6
13.55 - 15.55	---	26	1	---	27
15.55 - 17.55	---	13	11	---	24
17.55 - 19.55	---	---	12	---	12
19.55 - 21.55	---	---	7	---	7
21.55 - 23.55	---	---	1	4	5
23.55 - 25.55	---	---	---	1	1
25.55 - 27.55	---	---	---	1	1
Total number of fish	1	45	32	6	84
Mean length	10.30	14.82	18.44	23.45	16.74

TABLE VI: 2g. Length distribution of Age Groups for Gander River. (Sexes combined).

Fork Length (cms).	Age Groups				Total
	I^+	II^+	III^+	IV^+	
9.55 - 11.55	1	---	---	---	1
11.55 - 13.55	1	4	---	---	5
13.55 - 15.55	---	11	---	---	11
15.55 - 17.55	---	8	8	---	16
17.55 - 19.55	---	---	12	---	12
19.55 - 21.55	---	---	11	---	11
21.55 - 23.55	---	---	5	3	8
Total number of fish	2	23	36	3	65
Mean Length	11.45	14.56	19.38	22.47	17.56

TABLE VI: 2h. Length Distribution of Age Groups for Indian Bay Big Pond. (Sexes combined).

Fork Length (cms.)	Age Groups					Total
	II^+	III^+	IV^+	V^+	VI^+	
17.55 - 19.55	5	1	---	---	---	6
19.55 - 21.55	1	18	---	---	---	19
21.55 - 23.55	---	26	2	---	---	28
23.55 - 25.55	---	14	3	---	---	17
25.55 - 27.55	---	2	8	---	---	10
27.55 - 29.55	---	---	6	---	---	6
29.55 - 31.55	---	---	4	1	---	5
31.55 - 33.55	---	---	1	3	---	4
33.55 - 35.55	---	---	---	2	---	2
35.55 - 37.55	---	---	---	1	---	1
37.55 - 39.55	---	---	---	1	---	1
39.55 - 41.55	---	---	---	---	1	1
Total number of fish	6	61	24	8	1	100
Mean Length	18.89	22.34	27.32	34.06	40.10	24.55

TABLE VI: 2i. Length Distribution of Age Groups for Stephen's Pond. (Sexes combined).

Fork Length (cm.)	Age Groups					Total
	I^+	II^+	III^+	IV^+	V^+	
11.55 - 13.55	1	1	---	---	---	2
13.55 - 15.55	---	4	---	---	---	4
15.55 - 17.55	---	19	9	---	---	28
17.55 - 19.55	---	4	32	---	---	36
19.55 - 21.55	---	---	17	---	---	17
21.55 - 23.55	---	---	13	2	---	15
23.55 - 25.55	---	---	---	---	---	0
25.55 - 27.55	---	---	---	1	---	1
27.55 - 29.55	---	---	---	---	1	1
Total number of fish	1	28	71	3	1	104
Mean Length	12.00	16.59	19.44	23.80	29.00	18.82

TABLE VI: 2j. Length Distribution of Age Groups for Angle Pond. (Sexes combined).

Fork Length (cm.)	Age Groups					Total
	I^+	II^+	III^+	IV^+	V^+	
9.55 - 11.55	2	---	---	---	---	2
11.55 - 13.55	3	---	---	---	---	3
13.55 - 15.55	1	4	---	---	---	5
15.55 - 17.55	---	4	---	---	---	4
17.55 - 19.55	---	11	1	---	---	12
19.55 - 21.55	---	20	14	---	---	34
21.55 - 23.55	---	3	27	---	---	30
23.55 - 25.55	---	---	12	---	---	12
25.55 - 27.55	---	---	3	---	---	3
27.55 - 29.55	---	---	---	2	---	2
29.55 - 31.55	---	---	---	1	---	1
31.55 - 33.55	---	---	---	1	1	2
Total number of fish	6	42	57	4	1	110
Mean Length	12.01	19.18	22.67	29.97	32.50	21.11

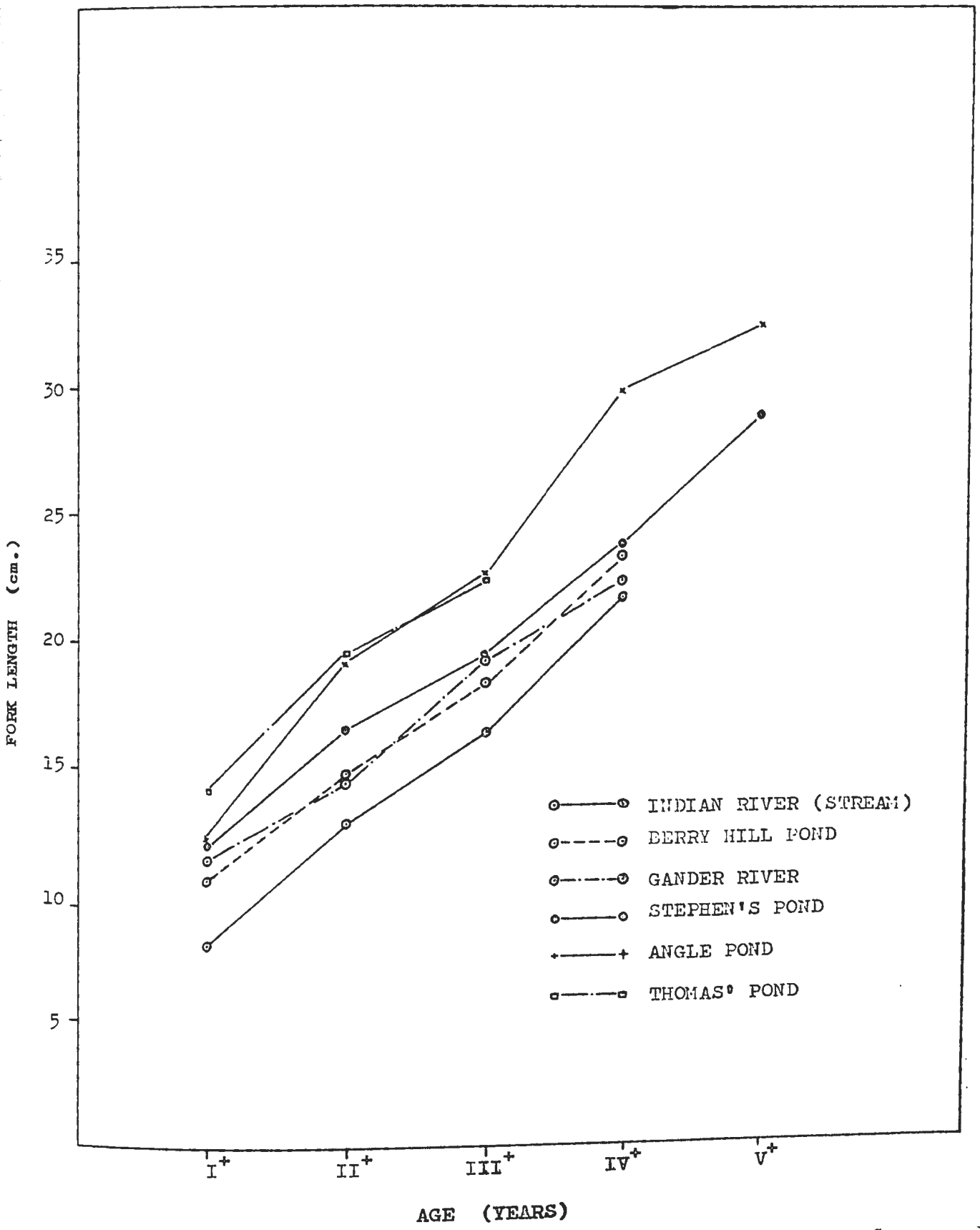


FIGURE VI: 2a. Average lengths (cm.) of the different age groups of speckled trout from various localities.

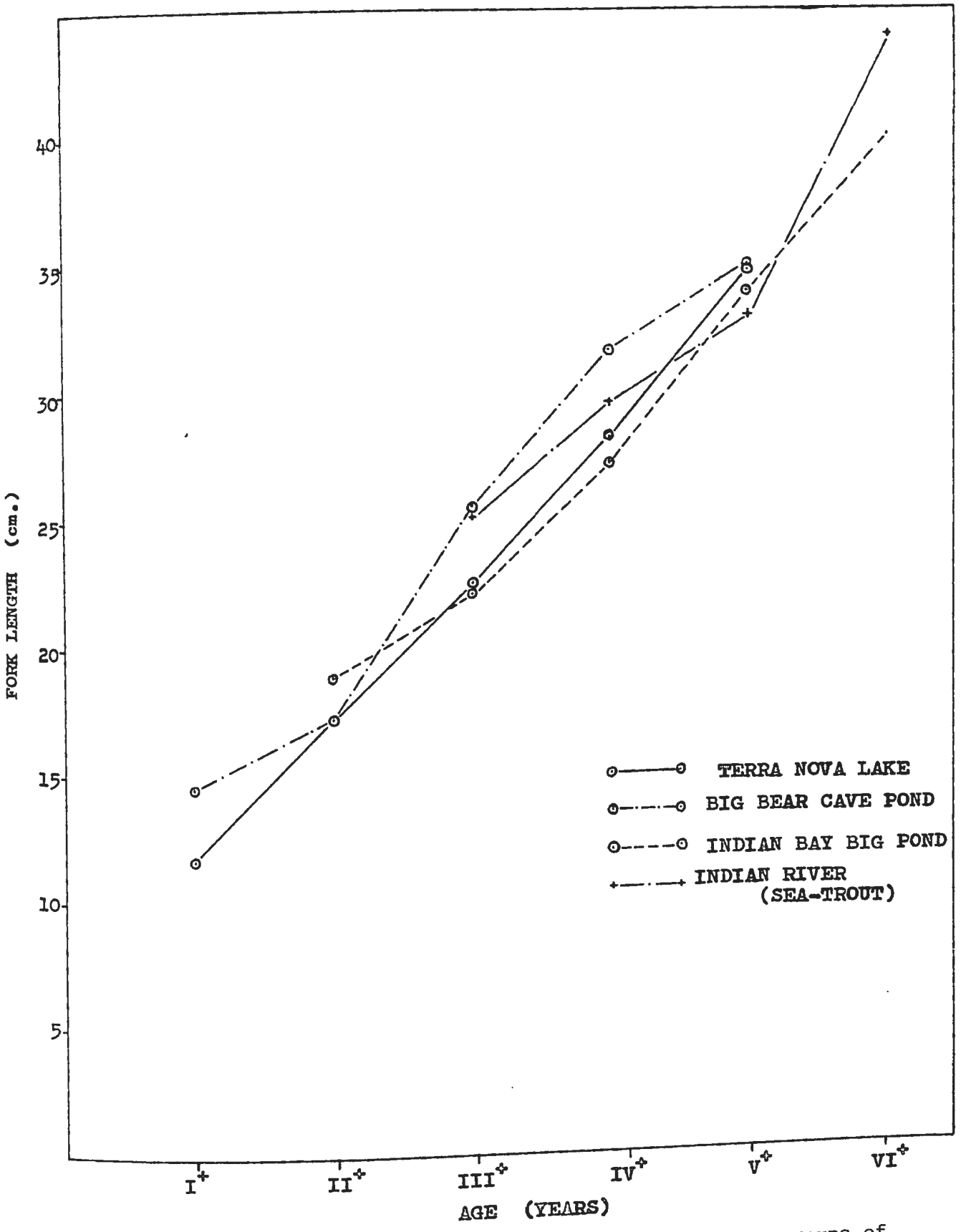


FIGURE VI: 2b. Average lengths (cm.) of the different age groups of speckled trout from various localities.

in growth rate of mud trout from brook to pond to lake?

Ricker (1932) considering the growth of Ontario trout, states, "the maximum size to which a speckled trout attains is apparently correlated with the size of the body of water in which it lives and more closely perhaps with the presence of suitable large foods; i.e., fish or crayfish." The absence of such food organisms of Ontario trout as suckers, minnows, catfish, trout-perch, perch, and sculpins would suggest that the maximum size attainable would be lower in Newfoundland waters. Frost (1940) suggests that probably a relatively slower growth rate occurs after the first two or three years because of the lack of suitable large food organisms such as forage fish, and this might cause the slower overall growth rate.

Figure VI: 2a. shows an increasing growth rate from Indian River (Twenty-three Mile Brook), Gander River, Berry Hill Pond (25 acres), Stephen's Pond (36 acres), to Angle Pond (90 acres).

Figure VI: 2b. shows the growth rates for the species in large ponds, lakes, and the sea. Thomas' Pond (256 acres) shows a slower rate than either Big Bear Cave Pond (1491 acres), Indian Bay Big Pond (2413 acres), or Terra Nova Lake (6211 acres); the latter three areas showing the fastest and somewhat similar rates of growth. It is also noted that the growth of sea-run trout taken at Indian River is perhaps not significantly greater than those of the species found in our larger lakes. Generally, though, the sea-run trout achieves a greater ultimate size than does its freshwater counterpart over the same life span.

The young sea trout and the trout destined to remain non-anadromous usually have a similar freshwater growth rate. However, as Wilder (1952)

suggests, the greatest difference in growth rate occurs during that year the young trout smolt migrates to sea. However, he suggests that in successive years the growth rate may be no faster than the freshwater form. White (1941) reports that in Nova Scotian waters sea trout gain as much as 3.7 cm. in 42-84 days at sea in their first exposure to the marine environment, and he also states that younger fish make the greatest gains. Because growth of the pre-smolt stage varies from habitat to habitat and since recent authors (Cooper, 1961; and Larkin, Terpenning, and Parker, 1955) have suggested growth is a function of size and not age, the smolt size is of prime importance in determining its growth potential in the sea. The smolts usually descend during their second and third year, and for Newfoundland and Nova Scotia the lengths at descent are very similar, 17.8 cm. and 17.5 cm. respectively, thus if environmental conditions in the sea are similar, we would expect similar growth rates which in fact we do find as we shall see later.

The contrasting growth rates of the sea-run and non-anadromous trout may be seen quite clearly in Figure VI: 2c, where growth is compared for Indian River sea-run and stream-resident populations. (Meristics indicate no genetic difference between the two populations and suggest the stream-resident fish are a combination of sea-run parr and smolt and a resident non-migratory adult stock). Ages III^+ and IV^+ contrasted show sizes of 16.24 cm. and 21.72 cm. for the stream residents, and 25.30 cm. and 29.61 cm. for the sea-run trout. The overall growth curves accentuate the difference and if we suppose these two groups to be genetically similar, the marked change in growth rate is environmentally induced, i.e., perhaps due to increased quality and quantity of food, and the influence of the "space factor".

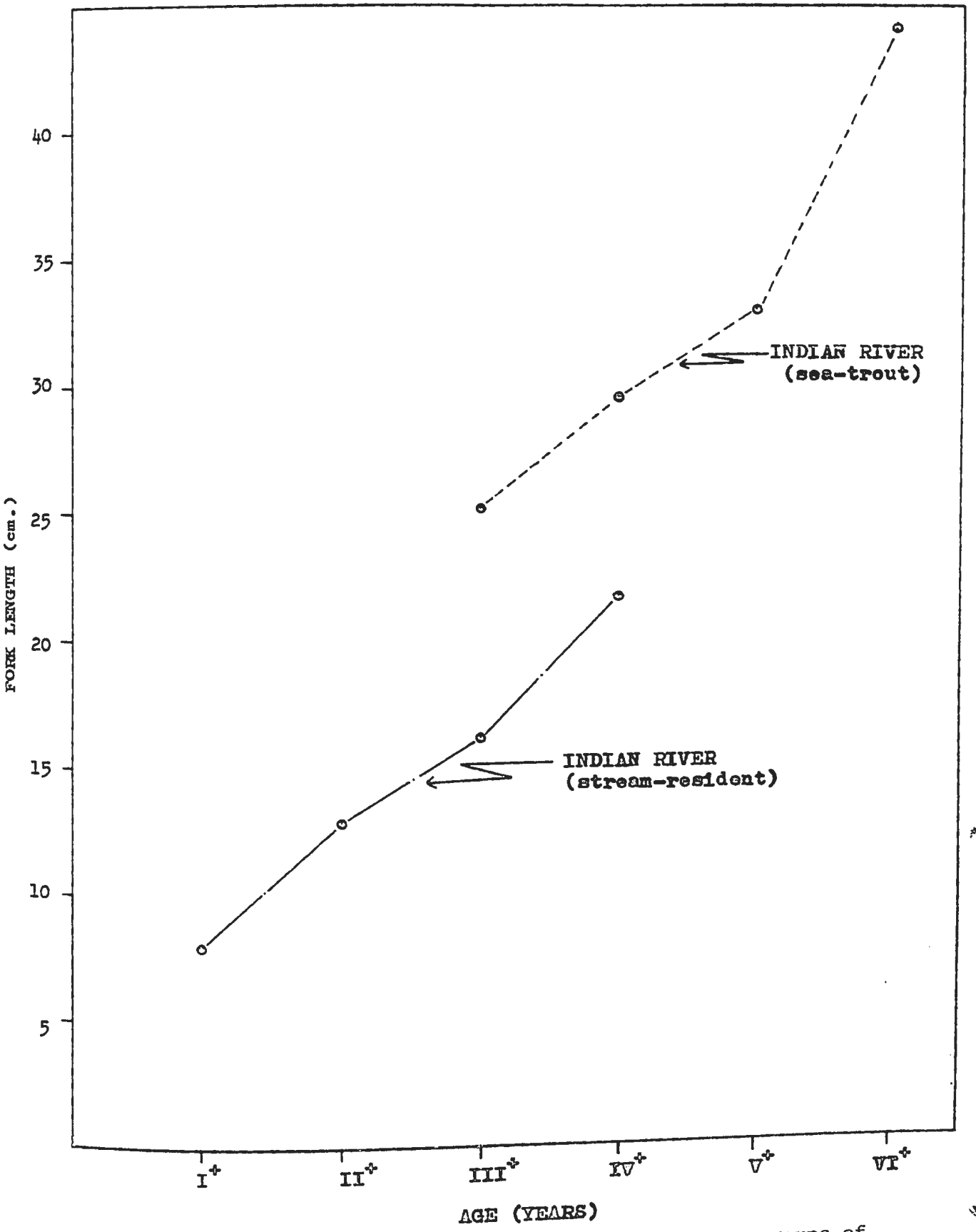


FIGURE VI: 2c. Average lengths (cm.) of the different age groups of Indian River sea and stream-resident trout.

It has already been suggested that growth differences are probably due to three broad factors, genetic, physiological, and environmental, but which of these is the most effective? If the sea-run trout and stream trout discussed previously are of the same genetic stock, it would appear that environmental factors are the dominating ones, and that they are able to mask genetic influences to some extent.

To elucidate this problem somewhat Greene (1955) questioned whether stunted speckled trout would grow. He states that many Wyoming streams are populated with stunted trout, and the angler's popular conception is that these stunted trout are inherently incapable of further growth. However, when transferred to nearby reservoirs these trout in less than one year showed average growth increases of 3.53 inches and 6.98 oz. It was found that the younger fish grew most rapidly, the duration of the stunted condition undoubtedly influencing the new growth potential. The reason given for increased growth was increased space and alkalinity; no difference in food supply was noted.

Rabe (1967) investigated growth differences in two lakes, and suggested slow growth in one lake was a combination of water quality (pH), duration of the growing season, food supply, and population density. Both lakes were similar in size and depth. Transplantation of the trout from the densely populated lake to the sparsely populated lake resulted in mean increases in growth of 2.1 inches and 6.2 oz. at the end of a seven week period. At the end of one year the transplanted trout were about 1 pound heavier and six inches longer than the control fish in the original lake. Rabe suggests decreased population density as the main reason.

Is the slow growth of speckled trout in this Province's small streams and rivers a local phenomenon or is it a general situation throughout its range?

Numerous authors (Kendall and Dence, 1927; Greeley, 1934; Moore et al., 1934; Hoover, 1939; Watts et al., 1942; Newell, 1956; Bridges, 1958; and Cooper, 1962) report that although speckled trout are common in many headwater streams from Maine to Georgia, the populations are often characterized by an abundance of small fish with most individuals requiring three or more years to reach legal size (six inches).

Hoover (1939) states that such cold headwater streams are considered by many as breeder streams, where large adults spawn, leave the area, fingerlings grow, and recruitment is added to the adult stock. However, Hoover suggests these "fingerlings" may be two or three years old, and he suggests that since speckled trout are relatively short lived they may never become available to the angler at such a slow growth rate.

Hoover suggests low summer water temperature is probably the major limiting factor. Hazzard (1932) has attributed slow growth in some New York streams to low water temperature and also low rate of removal and highly suitable spawning conditions. Hoover (1938) suggests these "short trout" streams in New Hampshire have seemingly suitable summer temperatures, but are seriously lacking in food. Cooper et al. (1962) shows that the slow growth in such streams may not be caused entirely by competition for food and space; a severe reduction in numbers did not result in subsequent substantial increase in growth rate.

Hoover (1939) states that many of the trout in these streams are deep bodied and suggests growth may not be critically slowed by lack of food.

He suggests probably as much food is taken in as can be utilized at the prevailing low water temperatures. Since the food supply is supplemented by terrestrial insects (similar at Indian River), it seems to Hoover that slow growth is due mainly to low temperatures.

Moore et al. (1934) reports on such a "short trout" stream with suitable water temperatures and food conditions and suggests inherited tendencies toward stunting are possibly important. However, Hoover (1938) suggests that it is unlikely that all such streams could be populated by a dwarfed race. The importance of such streams in management is obvious if the slow growth is not genetically but environmentally controlled as witnessed by the work of Greene (1955).

The work of Hoover (1938, 1939) and Hunt and Brynildson (1964) has shown that recruitment from such streams is low, and any recruitment is due to migration of larger (not necessarily older) trout in a reaction against limited space and water area of headwater streams.

The situation at Twenty-three Mile Brook, a headwater tributary of Indian River may be that of a true breeder stream, with a resident population of slow growing individuals. This is substantiated by the meristic similarity and by the fact that relatively few fingerlings or fry have been taken during electrofishing operations on the main river (Fisheries biologist, C. Sturge, pers. comm.).

The situation on the South-West branch of the Upper Gander River is not known; possibly it parallels the situation at Indian River, or the population may be strictly a resident one.

The general increase in growth rate from stream to pond to lake has generally been correlated with an increase in the number of suitable large

food organisms such as forage fish, etc.

Generally, smaller ponds are more productive overall than the larger deeper lakes, therefore we would expect larger population densities as is usually the case. However, since trout usually change their ecological niche with increasing size, a change in diet would be expected, and the unavailability of these larger food items results in a sharp decrease in growth rate rather than a slower gradual decrease.

Table 2 Appendix II shows the calculated yearly increments in length for sexes combined. It will be noted that in the larger ponds and lakes the increments in later years of life are not only larger but decline relatively slowly.

An analysis of the food of speckled trout (which will be dealt with later in more detail) indicates that generally trout taken from the more productive smaller bodies of water have a greater quantity and variety of food items; however quantity of food in the stomach alone may not bear a direct relationship with growth rate since as Brown (1946) suggests maintenance requirements vary, and growth depends on the amount of food which can be utilized above maintenance requirements.

Since trout may alter their potential to attain to an ultimate size through changes in feeding habits, beyond a certain age food quality undoubtedly becomes more significant than quantity. Trout which are able to make this change (usually gradual) are usually those which reach larger sizes, while those trout because of environmental deficiencies are unable to change their niche, show a continuing decline in growth.

Larkin, Terpenning, and Parker (1956) show that rainbow trout inhabiting lakes with other fishes show an increased growth rate over those

rainbow living in lakes where they are the only fish present. They suggest that in lakes where only the trout are present, growth rate is largely geared to the size of the population in relation to the level of lake productivity and appears to be regularly related to the age of the trout. However, in lakes with other fish species, the decline in growth with age and size is not uniform, suggesting that at certain ages or sizes, a change in trout - other species relationships results in a change in growth rate. They suggest it is due to the fact that the rainbow becomes piscivorous, which is related to size.

Greely (1927), Nurnberger (1930), Munro and Clemens (1937, Larkin, Terpenning, and Parker,(1956); and Crossman (1959) suggest that presence of forage fish reduces the growth rate of young salmonids because of competition but increases the growth rate of larger individuals.

Larkin et al. (1950) suggests that the slow transition from plankton feeding in young stages to a mixed diet of pelagic and benthic fauna and surface insects for larger fish is not sufficient an ecological change to alter their growth relationships. Thus the presence of forage fish and large food items is necessary if the fish is to embark on a new growth relationship, or to have a "new lease on life".

It does not seem surprising that there is no sharp inflection point indicating a threshold size for entering a new growth phase, and Larkin et al. (1956) suggest that if a threshold size does indeed exist, it may be reached part way through the growing season, and besides the change over to a piscivorous diet usually takes place gradually.

(b) Log Regression Age-Length Relationship

For easier graphical comparison and to obtain a mathematical expression

for growth in length the age-length data were transformed to the log regression form:

Log L = n log A + log a, which is the logarithmic form of the exponential $L = aA^n$.

The expression $L = aA^n$ has yielded exponential values of approximately 0.5 - 0.7, therefore speckled trout exhibit growth as would be expected, that is in the simplest terms $L \propto A^{2/3}$. Table 4, Appendix II shows both the calculated logarithmic and exponential forms with the corresponding standard errors of estimate calculated after Hoel (1965). Relationships are calculated for both sexes separated and combined.

The only other published data of this form were that of Allen (1956) who gave $L = 6.775\ A^{.7151}$ as the expression of growth in a Wyoming beaver pond; this expression agrees quite well with expressions derived in this study.

Table 3 Appendix II lists the calculated age-length data for both sexes separated and combined; the data are for all areas studied.

The calculated data for sexes combined are presented graphically in Figures VI: 3(a-b). The resulting straight line plots of the logarithmic regressions are of particular comparative value, more so than the empirical age-length plots of Figures VI: 2(a-b).

Because of the comparison value of the straight line plot, it was felt that this presentation would best illustrate differences in growth between the sexes.

The data for sexes separated from Table 3, Appendix II are presented graphically in Figures VI: 4(a-d). In only two instances are clear cut differences in growth between males and females exhibited. Females of

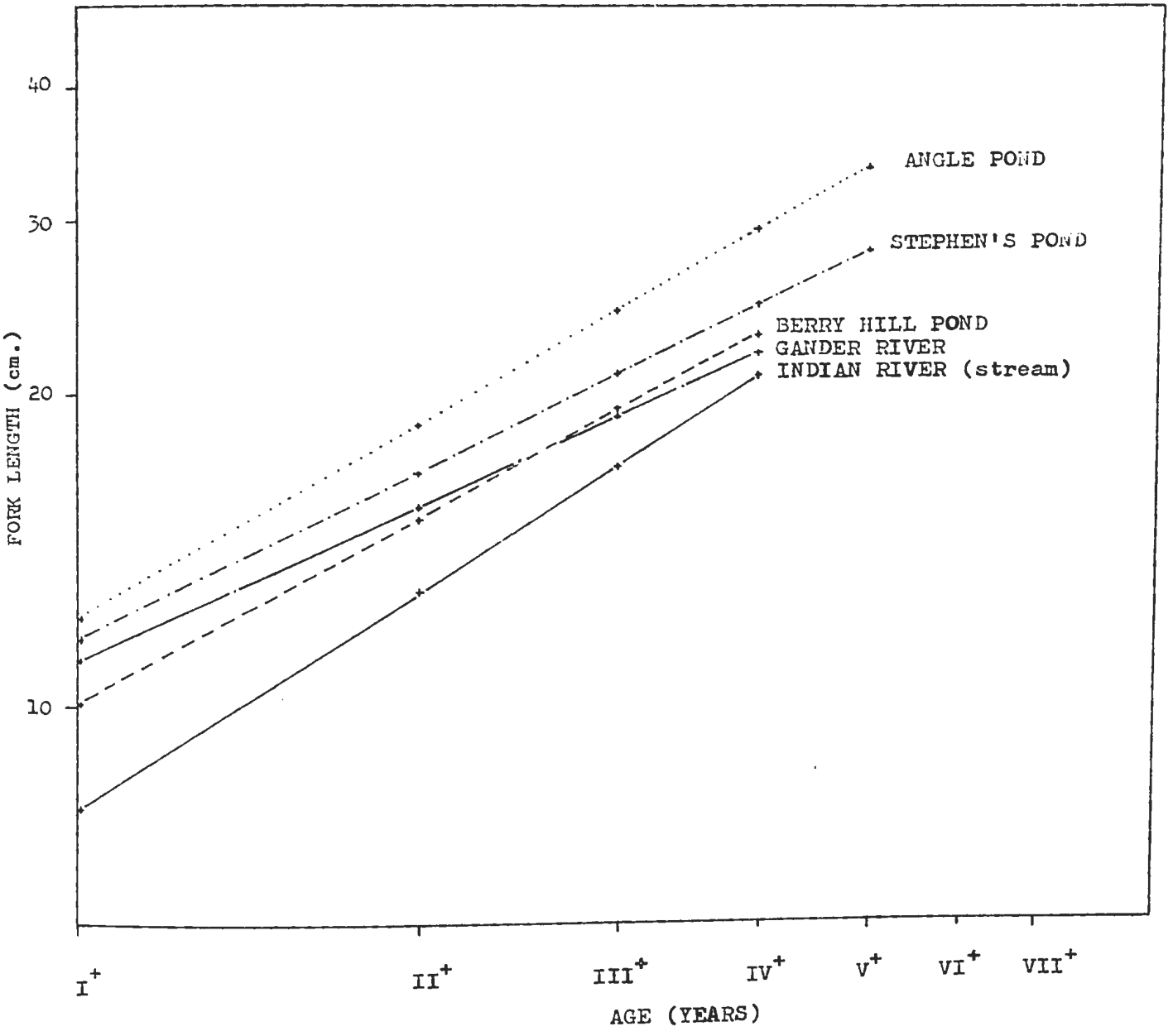


FIGURE VI: 3a. Calculated average lengths (cm.) of the different age groups of speckled trout from various localities.

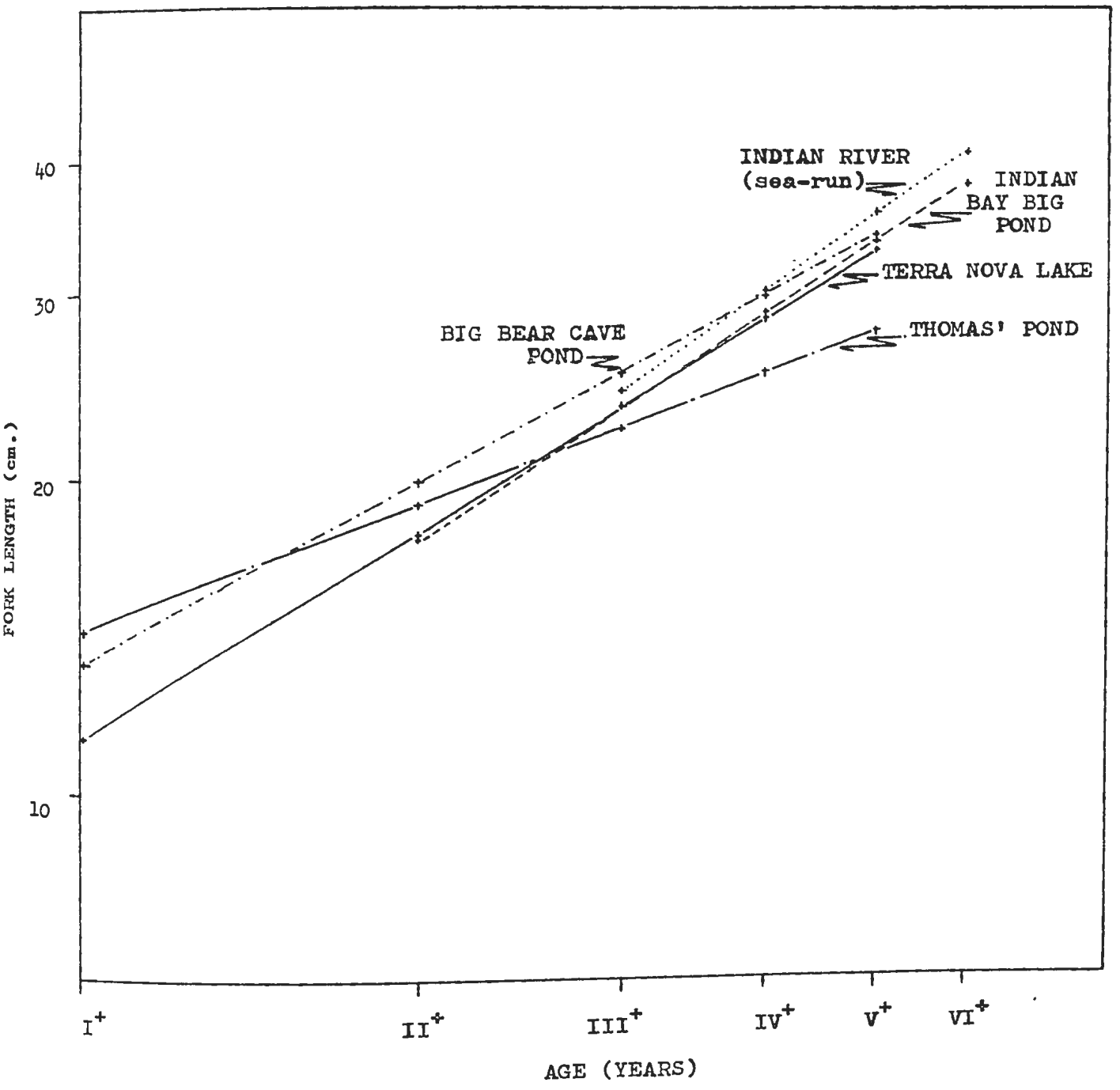


FIGURE VI: 3b. Calculated average lengths (cm.) of the different age groups of speckled trout from various localities.

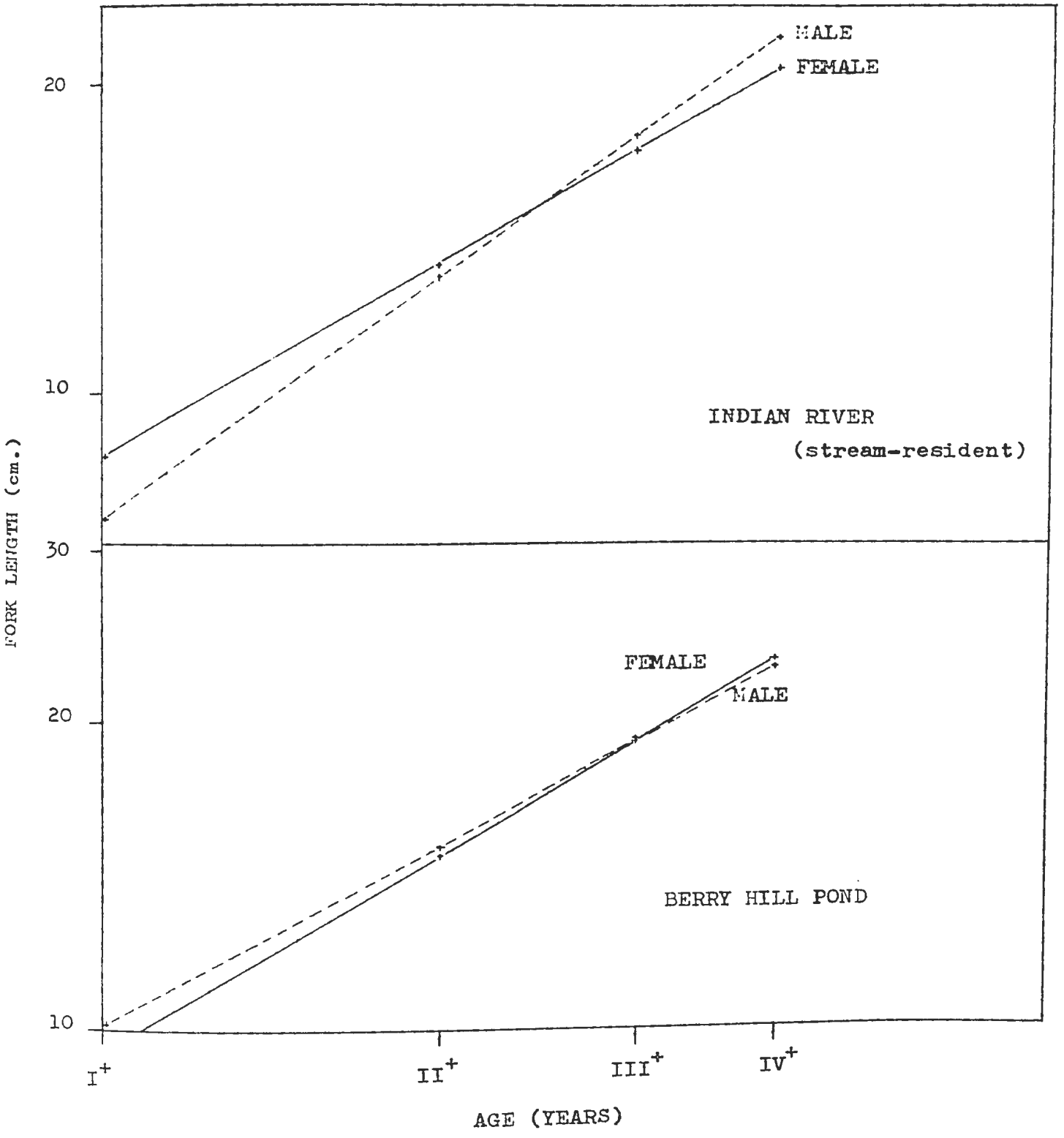


FIGURE VI: 4a. Calculated average lengths (cm.) of the different age groups of male and female speckled trout.

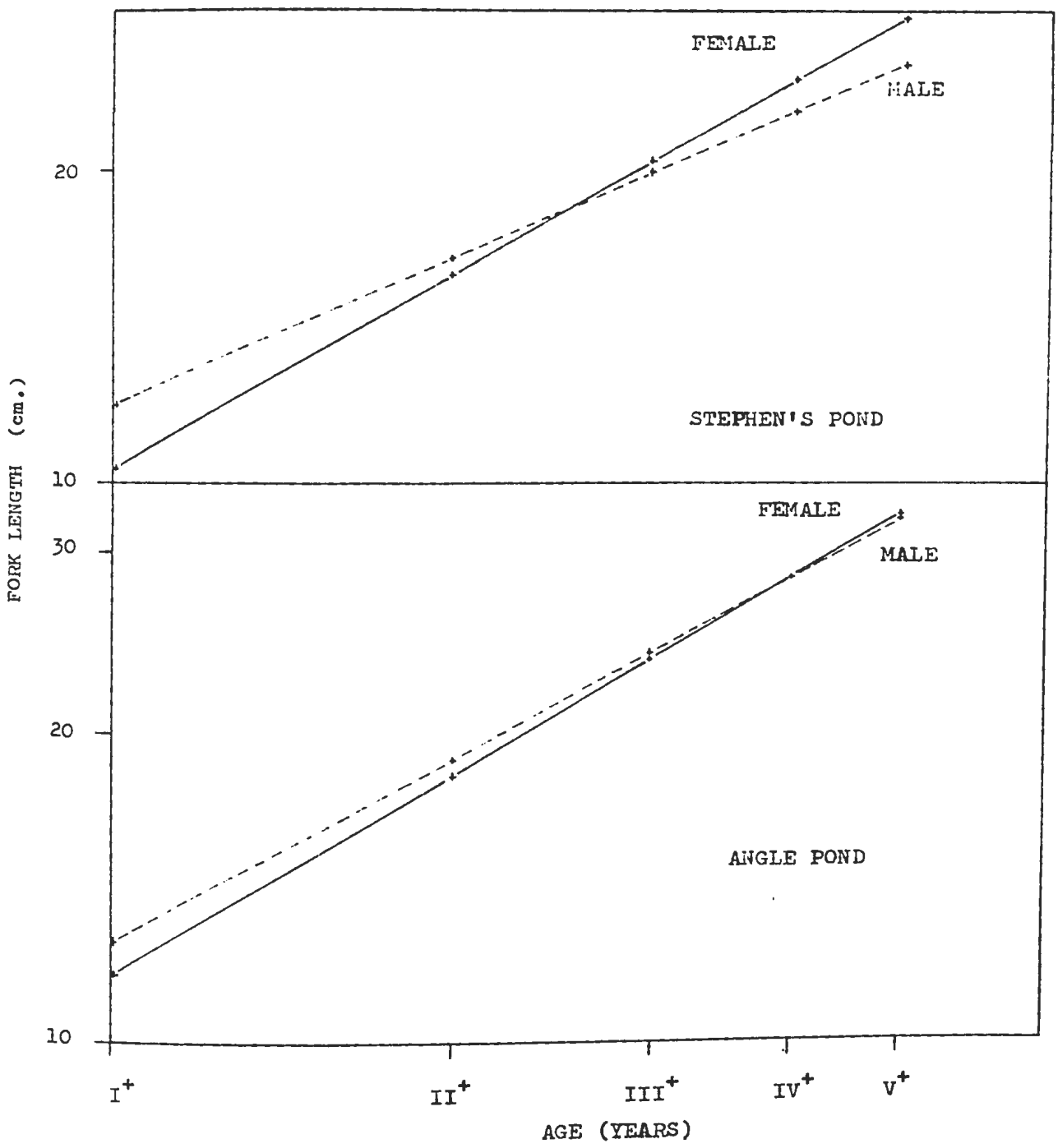


FIGURE VI: 4b. Calculated average lengths (cm.) of the different age groups of male and female speckled trout.

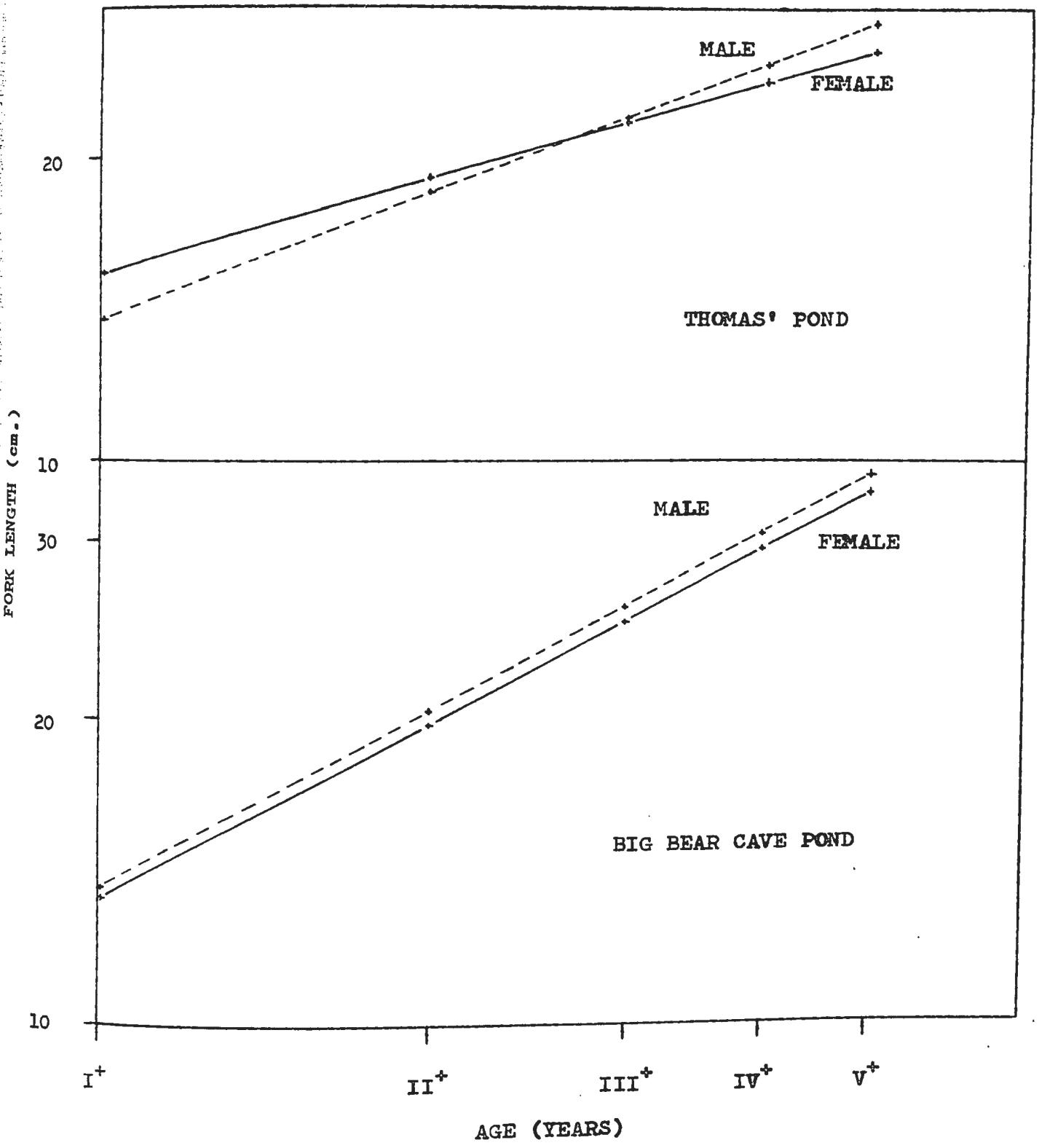


FIGURE VI: 4c. Calculated average lengths (cm.) of the different age groups of male and female speckled trout.

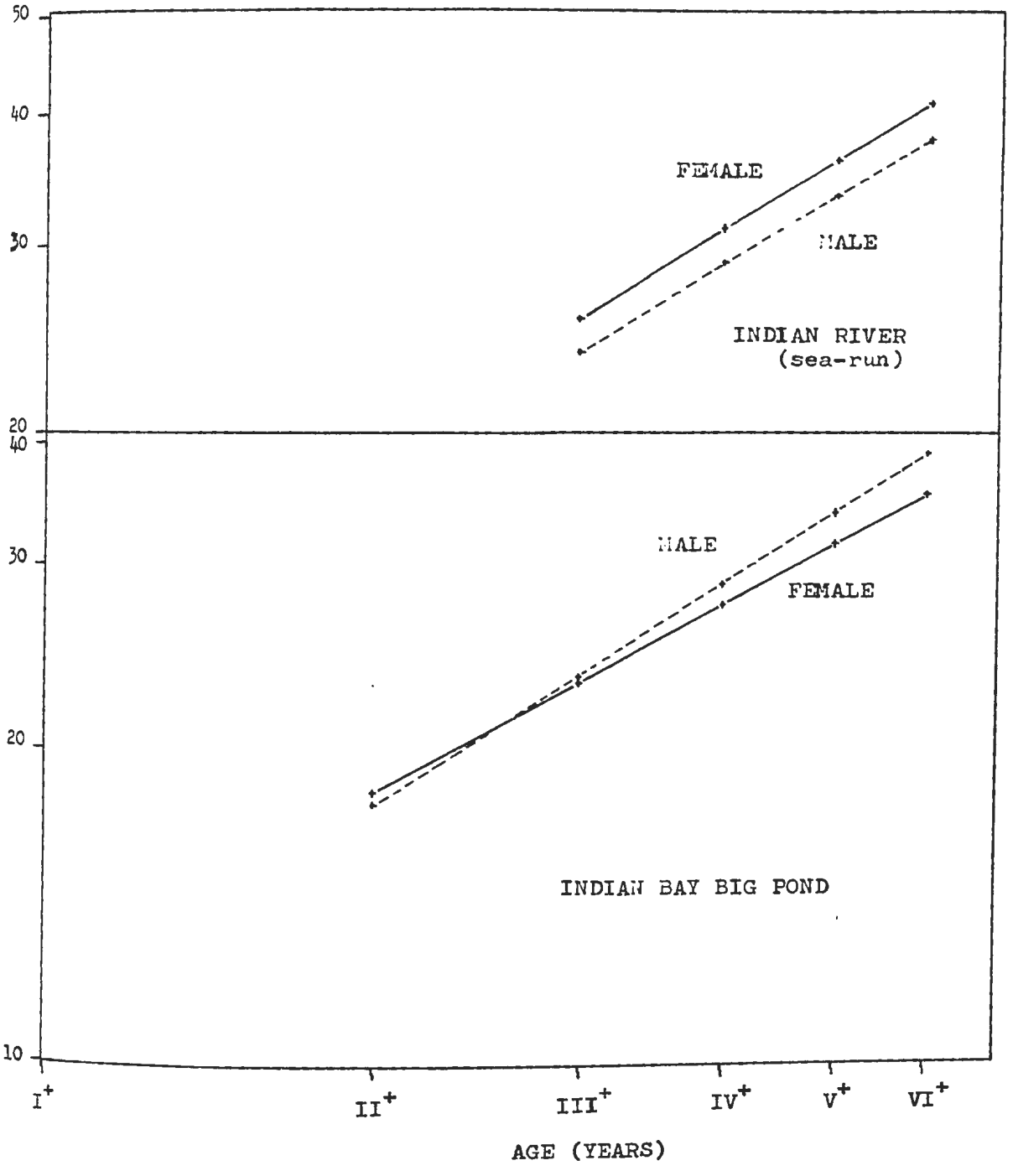


FIGURE VI: 4d. Calculated average lengths (cm.) of the different age groups of male and female speckled trout.

Indian River sea-trout are larger than males over all ages, however the small sample size does not permit any definite conclusion. Male trout in Big Bear Cave Pond were found to be consistently larger than females at all ages sampled, and the sample size seems adequate. In all other areas but one (Stephen's Pond), males appear to be growing faster in later years following an initial period when females grew faster.

Hoover (1939) states that for several New Hampshire streams "according to conventional methods of growth calculation, male brook trout grow slightly more rapidly than the females." However, differential growth between the sexes was rather slight with a maximum mean difference of one centimeter.

Allen (1956) states that there appeared to be no appreciable difference in growth between males and females in a Wyoming beaver pond; however, his data show slight differences (less than 1 cm.) favoring males. Cooper et al. (1962) in discussing Pennsylvania streams suggested males grew faster than females though the differences were quite small. However, he considered there would be little bias in combining sexes for growth studies.

McFadden (1961) states that in Lawrence Creek, Wisconsin the average length of male speckled trout of age groups 0, I, and II exceed that of females. Electrofishing yielded a mean length of 4.45 inches for males and 4.10 inches for females; the difference was significant at a probability level of 0.01. Similarly, anglers catches showed males to be significantly larger. He suggests that 54 per cent of the anglers catch were males and since angling selects faster growing fish, the observed difference was real. McFadden suggests that the data infers the difference occurs during the first ten months of life, and thereafter both sexes grew at the same rate. However,

because of selective sampling by angling he suggests the difference between males and females increases with age.

This may then explain why only at Stephen's Pond were females larger than males at older ages as heavy angling probably cropped the faster growing males. The sex ratio also indicates this possibility with 61 per cent females.

Angle Pond, where angling intensity is also high, shows males growing faster throughout except at the older ages where there is little difference. Here again selective cropping of faster growing males may be the reason as the sex ratio favors females 62:48.

It is of particular interest to note that in areas where angling is light, the differences favoring males are more pronounced (Indian Bay Big Pond, Big Bear Cave Pond, Berry Hill Pond, and Indian River).

(c) Comparison of Growth with Other North American Localities

Frost (1940) suggests that because of the unavailability of larger foods large trout would not be expected to be found in Newfoundland; a relatively slow growth rate should be general, especially after two or three years.

Scott and Crossman (1964) in comparing growth rates state that trout in the Moser River, Nova Scotia, grew more slowly than Newfoundland trout in the early years but exceeded them in the later years. However, growth in some small Nova Scotia brooks was found to be slower than that for Oliver's Brook (Newfoundland). They also report growth in Lake St. George (Newfoundland) to be good in early years but slower at older ages and compared with the Nova Scotia data indicates the relative abundance of food for younger trout but the scarcity for older fish.

In order to make the comparison of data between Newfoundland waters and those of the rest of North America valid, it was decided to compare the growth rates of trout from similar habitats. The habitat type was divided into three divisions: (1) streams, creeks, small rivers, and small ponds; (2) medium sized ponds (not greater than 1000 acres); and (3) large ponds and lakes (greater than 1000 acres).

Tables VI: 3(a-c) give the age length data for various North American localities, and the data are presented graphically in Figures VI: 5(a-c).

Figure VI: 5a indicates that speckled trout in streams, rivers, and small ponds, etc., are growing as well if not better in Newfoundland waters than in various mainland waters of comparable size. The data from Twenty-three Mile Brook (Indian River), South-west Gander River tributaries, and Berry Hill Pond were combined for calculation of growth in Newfoundland waters.

Figure VI: 5b. shows growth for Ontario, Saskatchewan, Wisconsin, and Newfoundland. It appears that growth in medium sized ponds is relatively good at early ages for Newfoundland but growth tapers off in later years and is behind that of the other areas. This is again indicative of the lack of suitable large food organisms. The Newfoundland data were compiled from Stephen's Pond, Angle Pond, and Thomas' Pond.

The comparative growth rates in large ponds and lakes are given in Figure VI: 5c. and indicate growth in Newfoundland is perhaps only better than in Saskatchewan. However, the data from Saskatchewan is based on only one lake and Rawson (1940) states that the growth rate has decreased somewhat from the time of first planting. The Newfoundland data may be biased somewhat in that included are prize trout taken in the relatively inaccessible and lightly fished Indian Bay Area. Other areas included are Big Bear Cave Pond,

TABLE VI: 3a. Comparison of growth rates of speckled trout from streams, rivers, creeks, and small ponds for five different North American localities.

Age (Years)	FORK LENGTH (CM.)				
	New Hampshire (Hoover,1939)	Michigan (Shetter & Leonard,1943)	Wyoming (Allen, 1956)	Nova Scotia (Wilder, 1952)	Nfld. (This thesis)
I^+	7.3	6.7	10.9	10.4	9.9
II^+	9.9	11.2	15.0	14.5	14.1
III^+	12.4	15.3	18.6	17.2	18.0
IV^+	16.6	---	---	20.2	22.5
V^+	---	---	---	28.1	---

TABLE VI: 3b. Comparison of growth rates of speckled trout from ponds (not greater than 1000 acres) for four different North American localities.

Age (Years)	FORK LENGTH (CM.)			
	Wisconsin (McFadden,1961)	Ontario (Ricker, 1932)	Saskatchewan (Rawson,1940)	Nfld. (This thesis)
I^+	16.9	12.9	6.5	12.7
II^+	21.3	18.5	15.6	18.4
III^+	27.0	26.5	22.1	21.4
IV^+	31.5	35.2	28.2	26.9
V^+	---	---	33.8	30.8
VI^+	---	---	37.8	---

TABLE VI: 3c. Comparison of growth rates of speckled trout from large ponds, lakes (greater than 1000 acres) and sea run for six different North American localities.

Age (Years)	FORK LENGTH (CM.)						
	Maine (Havey, 1961)	Nfld. (This thesis)	Sask. (Rawson 1940)	Man. (Doan 1948)	Utah (Hazzard, 1935)	N.S. (sea-run Wilder, 1952)	Nfld. (This thesis)
I^+	---	13.2	6.5	20.3	10.3	---	---
II^+	23.3	17.9	15.0	26.7	18.7	20.7	---
III^+	30.0	23.5	21.6	36.5	23.8	25.4	25.3
IV^+	36.6	29.1	26.7	43.3	29.0	28.1	29.6
V^+	43.1	34.4	30.3	49.6	---	34.2	33.1
VI^+	47.1	39.8	34.3	53.1	---	40.4	44.1
VII^+	---	45.6	36.8	---	---	---	---
$VIII^+$	---	48.5	---	---	---	---	---

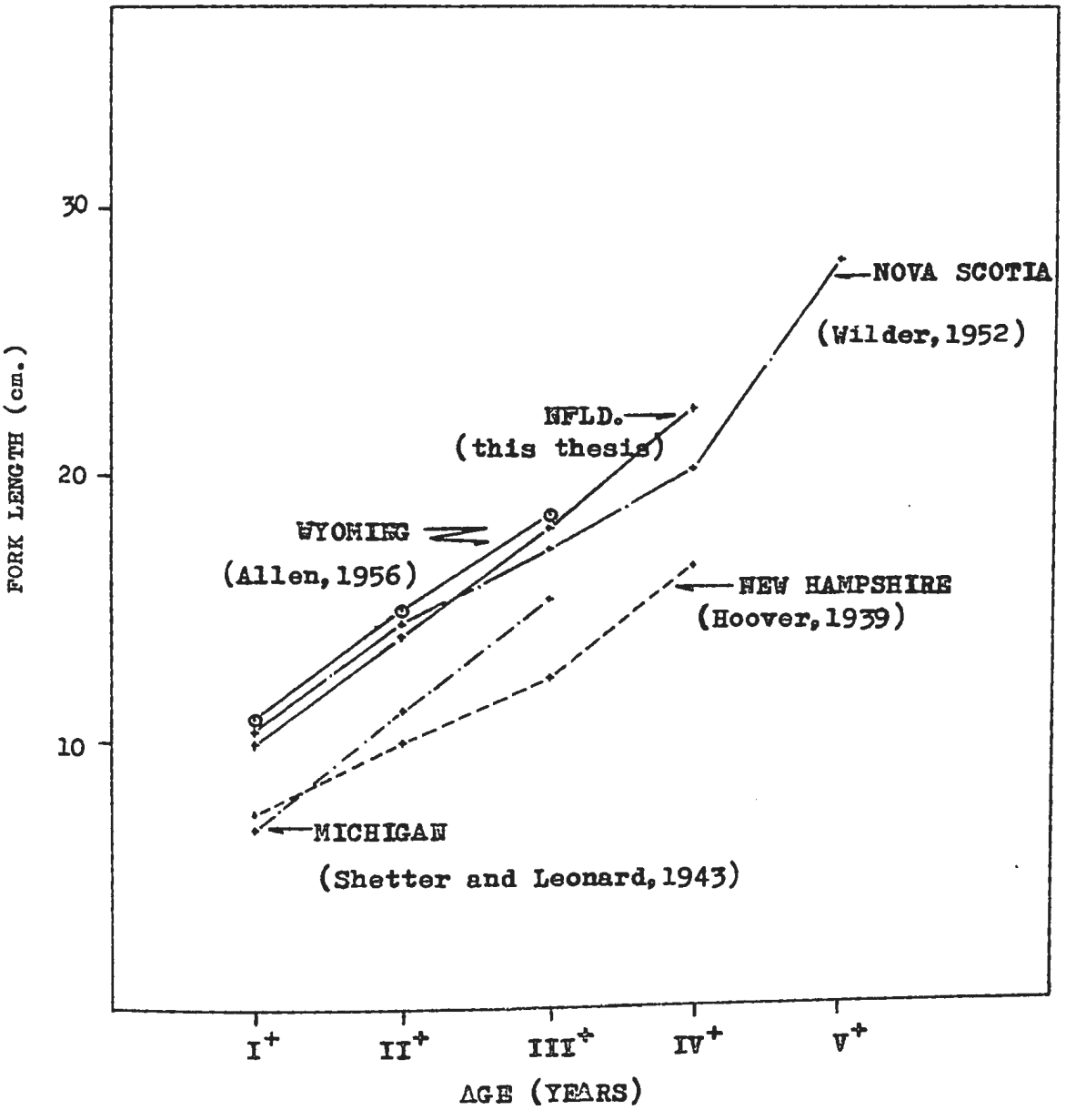


FIGURE VI: 5a. Growth in length for speckled trout in streams, rivers, and small ponds from various North American localities.

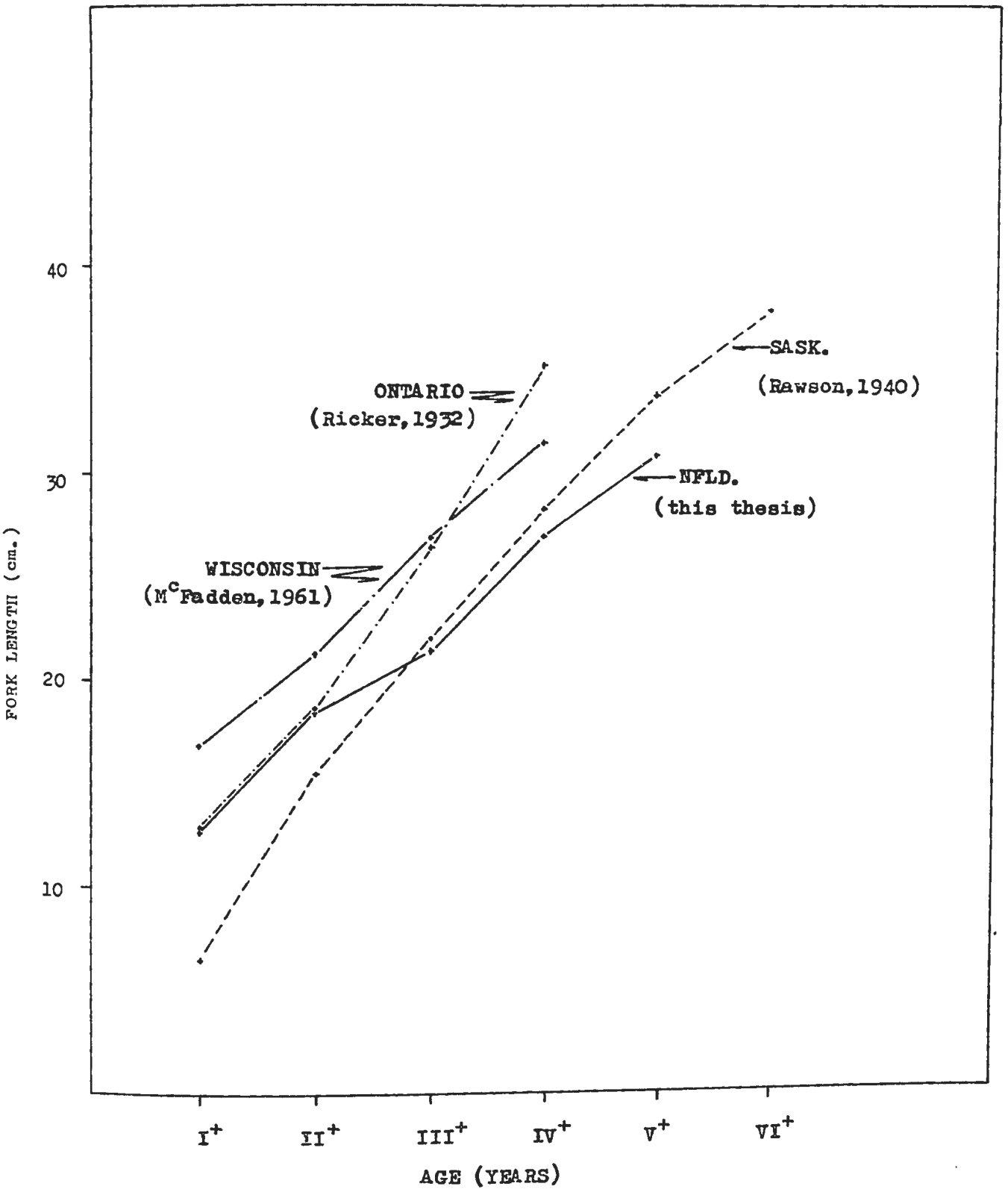


FIGURE VI: 5b. Growth in length for speckled trout in medium sized ponds from various North American localities.

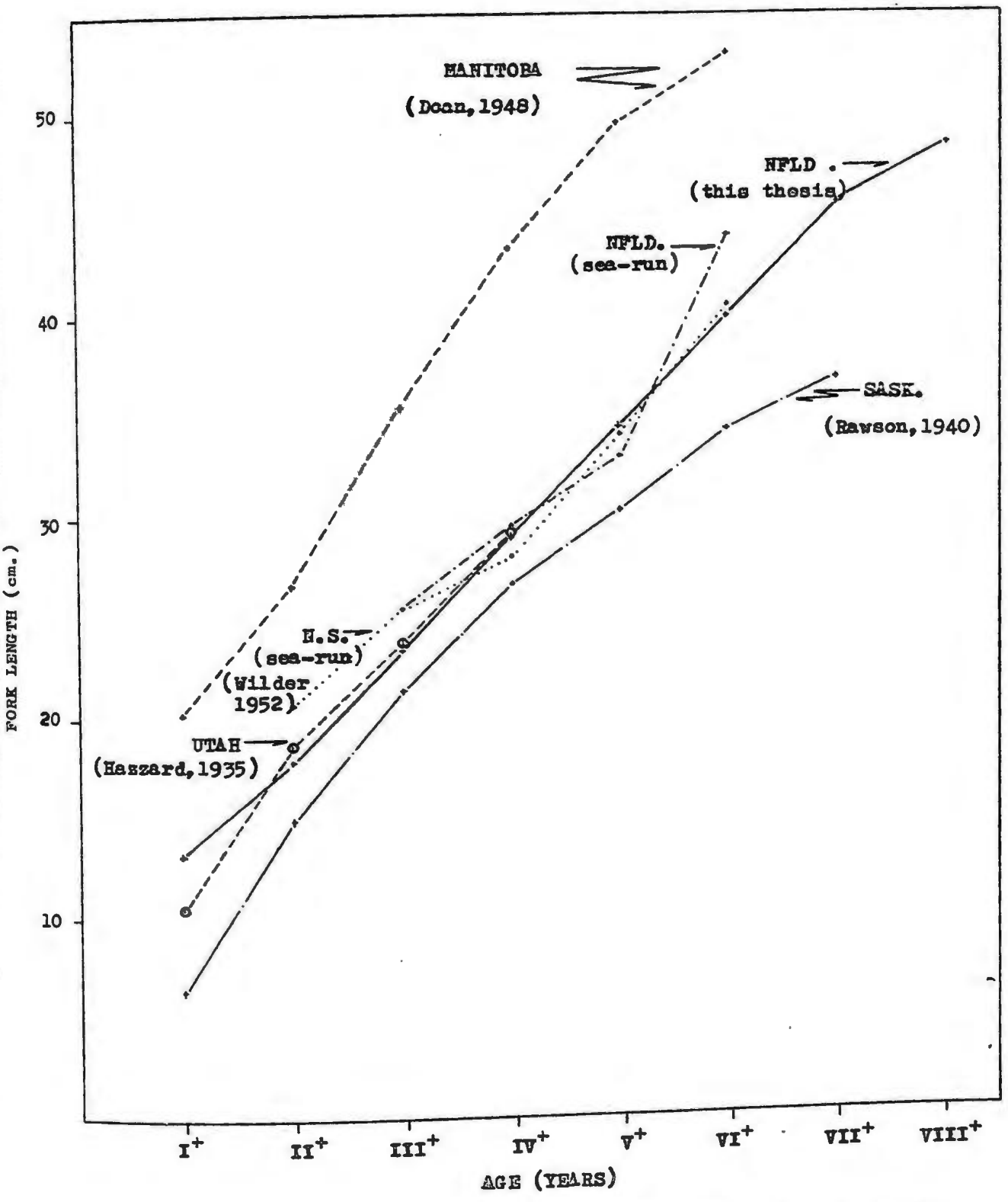


FIGURE VI: 5c. Growth in length for speckled trout in large ponds and lakes from various North American localities.

Indian Bay Big Pond, and Terra Nova Lake.

Figure VI: 5c. also compares the growth of Wilder's (1952) Moser River (Nova Scotia) sea-trout and those of Indian River. The growth pattern of these two populations is remarkably similar and this is not unusual when we recall that the smolt of both areas are approximately the same size and growth is a function of size. However, it must be kept in mind that the Indian River sample is small.

2. Relative Growth

Relative growth is usually defined as percentage growth in which the increase in growth in each time interval is expressed as a percentage of the growth at the beginning of the time interval.

The greatest difference between relative and absolute growth comes in early life since slow growth of old age differs little with regard to method of approach. The absolute growth, as we have seen, takes the form of a sigmoid curve; relative growth on the other hand is most rapid in early life and declines constantly thereafter.

Instantaneous growth rates were calculated by converting the mean length of fish of a given age to the natural logarithm and using the formula:

$$G = \log_e Lt - \log_e Lo$$

where G is instantaneous growth rate

Lt is the length at the end of age t

and Lo is the initial length.

The use of instantaneous growth rates has found wide use in fishery biology, although it is recognized that growth is not positively exponential throughout the fish's life (Ricker, 1958). Therefore instantaneous growth ideally should be used for comparatively short segments of the entire growth

history. Generally however, most growth studies are based on length differences on an annual basis because of the use of the scale method of age determination.

The annual instantaneous growth rates for speckled trout in Newfoundland are given in Table VI: 4. Growth rates are calculated both from expirical data (Ga) and from calculated length data (Gc).

Generally, the growth trend is one of decreasing growth rate throughout the period of the fish's life span. The rate of decline of growth rate also shows a decrease with age. This is in general agreement with the suggestions of Minot (1890).

It is noteworthy that the highest relative growth in all cases is during the first year of life (age 0 to age I). It is also of particular interest that the rate of decline of growth rate with increased age is less in larger bodies of water. This is seen more readily when considering Gc.

Larkin, Terpenning, and Parker (1956) suggest the use of size-specific instantaneous growth rates for comparisons, suggesting there is a close relationship between size and growth rate. They suggest direct comparison of rates for fish of the same age is only valid when fish of comparable length are used; otherwise, differences in rate will not only reflect differences in size, but also the size in relation to the ecology of the body of water.

TABLE VI: 4. Specific growth rates of speckled trout from various localities in Newfoundland. (Ga calculated from actual increments and Gc from calculated increments.)

Years	Specific Growth rate					
	Indian River (Stream)		Gander River		Berry Hill Pond	
	Ga	Gc	Ga	Gc	Ga	Gc
0 - I	2.08	2.07	2.44	2.41	2.33	2.31
I - II	.47	.48	.24	.34	.36	.40
II - III	.23	.28	.28	.20	.22	.24
III - IV	.29	.20	.15	.13	.24	.17

	Stephen's Pond		Angle Pond		Thomas' Pond	
	Ga	Gc	Ga	Gc	Ga	Gc
0 - I	2.49	2.45	2.48	2.49	2.65	2.66
I - II	.32	.37	.47	.43	.32	.28
II - III	.16	.21	.17	.25	.13	.16
III - IV	.20	.15	.28	.18	---	.12
IV - V	.20	.12	.08	.14	---	.09

	Big Bear Cave Pond		Indian Bay Big Pond		Terra Nova Lake	
	Ga	Gc	Ga	Gc	Ga	Gc
0 - I	2.68	2.60	---	2.41	2.47	2.43
I - II	.17	.40	---	.48	.38	.46
II - III	.38	.24	.17	.28	.27	.27
III - IV	.22	.16	.20	.20	.22	.19
IV - V	.10	.13	.22	.15	.21	.15
V - VI	---	---	.16	.13	---	---

C. Growth in Weight

Growth studies of many animals have often been undertaken on a basis of gain in weight, for the simple reason that since growth is manifested as an increase in size it is best measured in terms of volume or weight. Growth studies based on weight have obvious advantages in production studies. However, as we have already seen, most studies of piscine growth utilize length as the dimension under consideration, as it has been shown that the relationship of length to weight holds fairly constant for a species.

Cooper (1961) however suggests that both length and weight are usually used in critical studies.

Weight of fishes may be considered a function of length and the exact nature of this relationship will be seen when the length-weight relationship is considered.

Growth in weight is unique in that it is not always positive. Cooper (1961) states that speckled trout commonly lose weight (negative growth rate) during many of the winter months. McFadden (1961) suggests that superimposed on the theoretical curve of decline of growth in weight with increased age are seasonal fluctuations of positive and negative growth. The negative growth occurs in winter and the greatest loss occurs with the more extreme seasonal climatic variations.

The empirical age-weight whole data for sexes separated and combined are given in Table 5 Appendix II, and the data for sexes combined are presented graphically in Figures VI: 6 (a-b).

As with growth in length, growth in weight exemplifies the direct relationship of growth rate with habitat area.

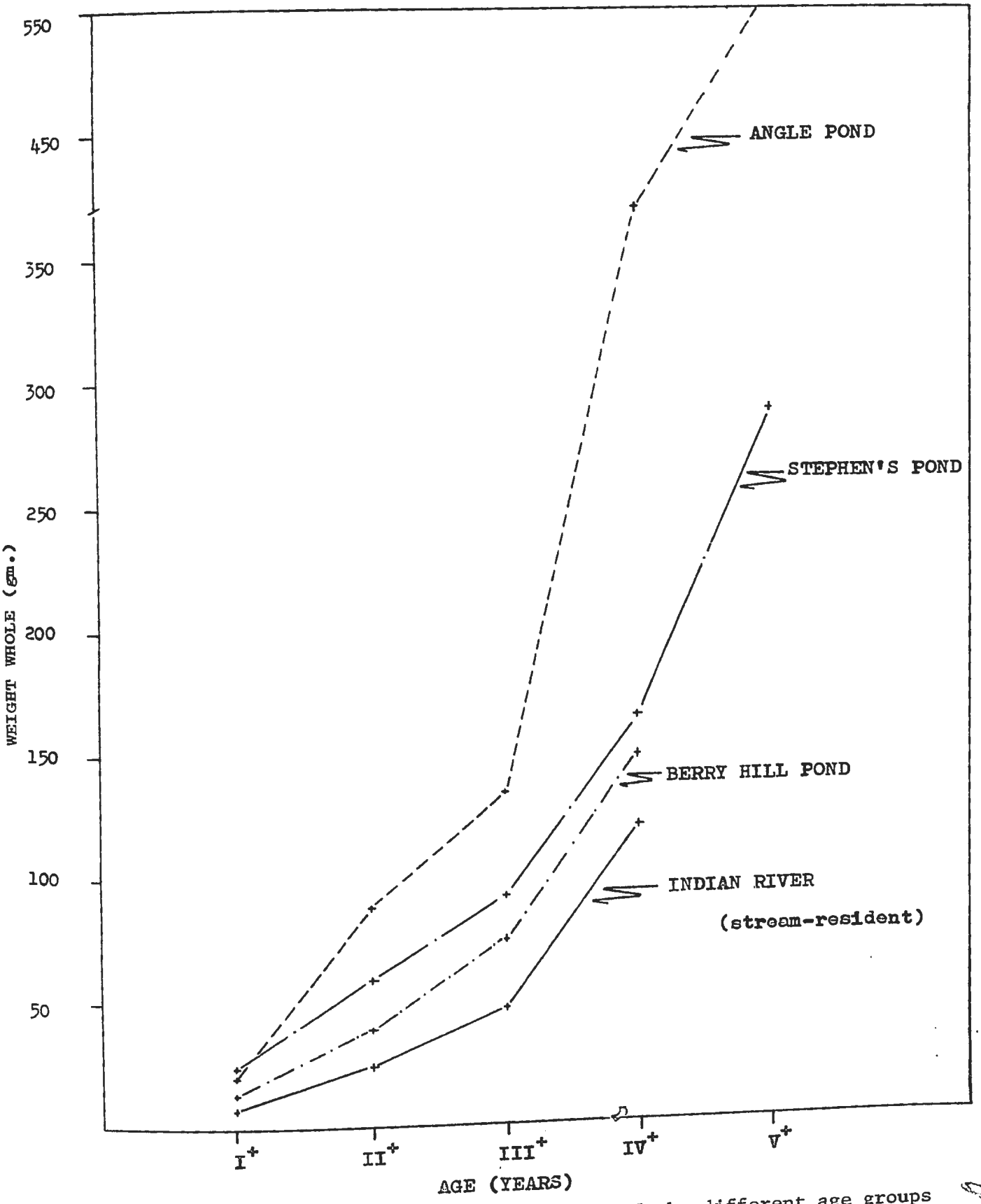


FIGURE VI: 6a. Average whole weights (gm.) of the different age groups of speckled trout from various localities.

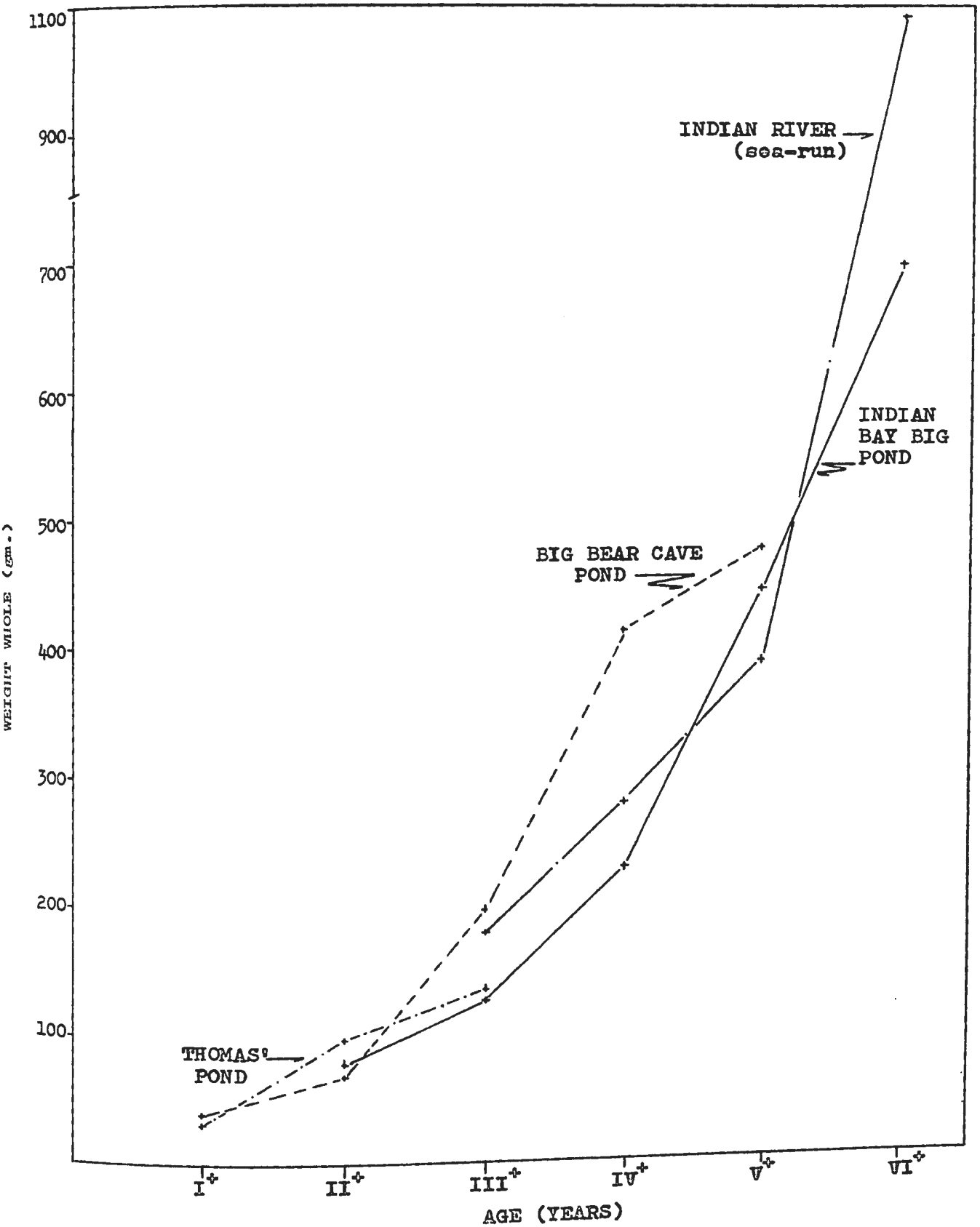


FIGURE VI: 6b. Average whole weights (gm.) of the different age groups of speckled trout from various localities.

For easier graphical comparison and for an expression of growth in weight, the data were transformed to the log regression form and the calculated relationships for sexes separated and combined are given in Table 6 Appendix II, with the corresponding standard errors of estimate. Calculated whole weights were derived from the age-weight relationship and are given in Table 7 Appendix II, and are presented graphically for sexes combined in Figures VI: 7 (a-b).

The log regression transformations were of the form:

$\log W = n \log A + \log a$, which is from the exponential: $W = a A^n$.

The values of the exponent n are given in Table 6 Appendix II and range from approximately 1.4 - 2.4, with an approximate mean value of 2. This implies that in simplest terms, approximately, $W \propto A^2$. This is as would be expected since approximately $W \propto L^3$ and $L \propto A^{2/3}$; substituting yields $W \propto A^2$.

To remove the influence of seasonal variation in gonad weight, visceral fat content, and stomach contents, growth was described in terms of gutted weight, with the data on age-weight gutted given in Table 8 Appendix II. The data for sexes combined are illustrated graphically in Figures VI: 8 (a-b). Relative differences in growth based on whole and gutted weight are not apparent and significant differences in growth rate between areas are not thought to be influenced unduly by relative differences in gonad weight, fat content, or stomach contents.

The age-weight gutted data were also transformed to the log regression form, and calculated gutted weights given in Table 9 Appendix II are presented graphically in Figures VI: 9 (a-b) for sexes combined.

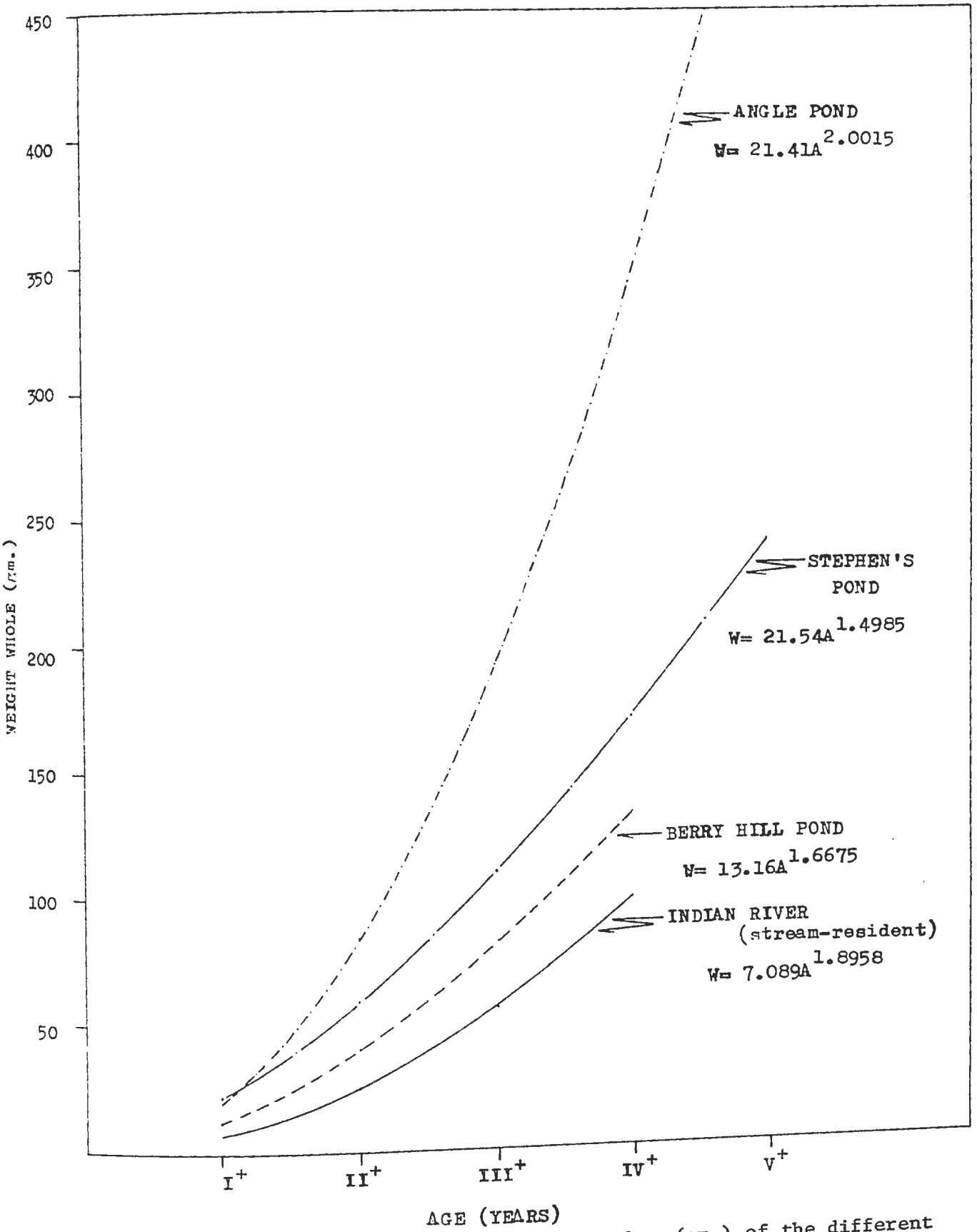


FIGURE VI: 7a. Calculated average whole weights (gm.) of the different age groups of speckled trout from various localities.

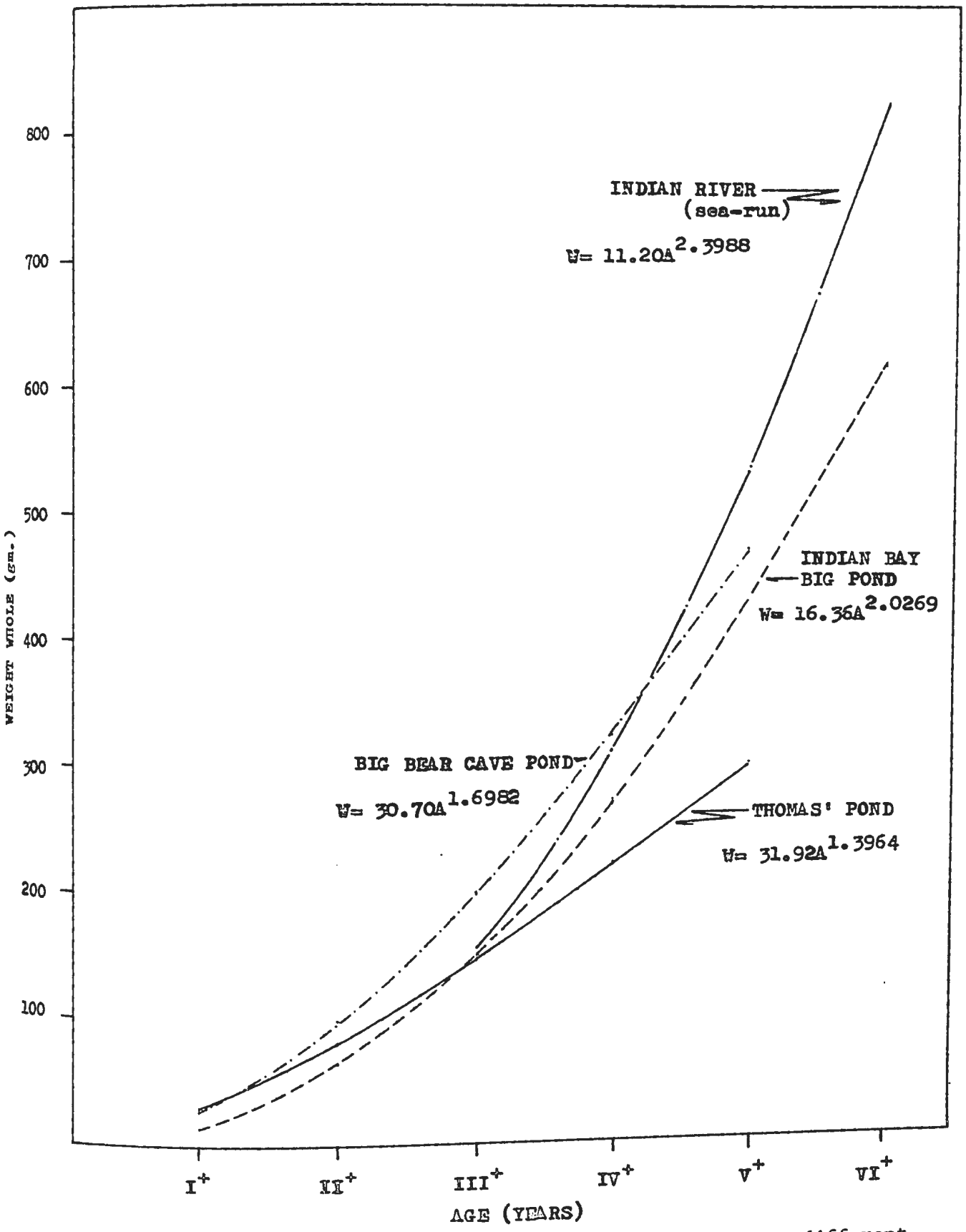


FIGURE VI: 7b. Calculated average whole weights (gm.) of the different age groups of speckled trout from various localities.

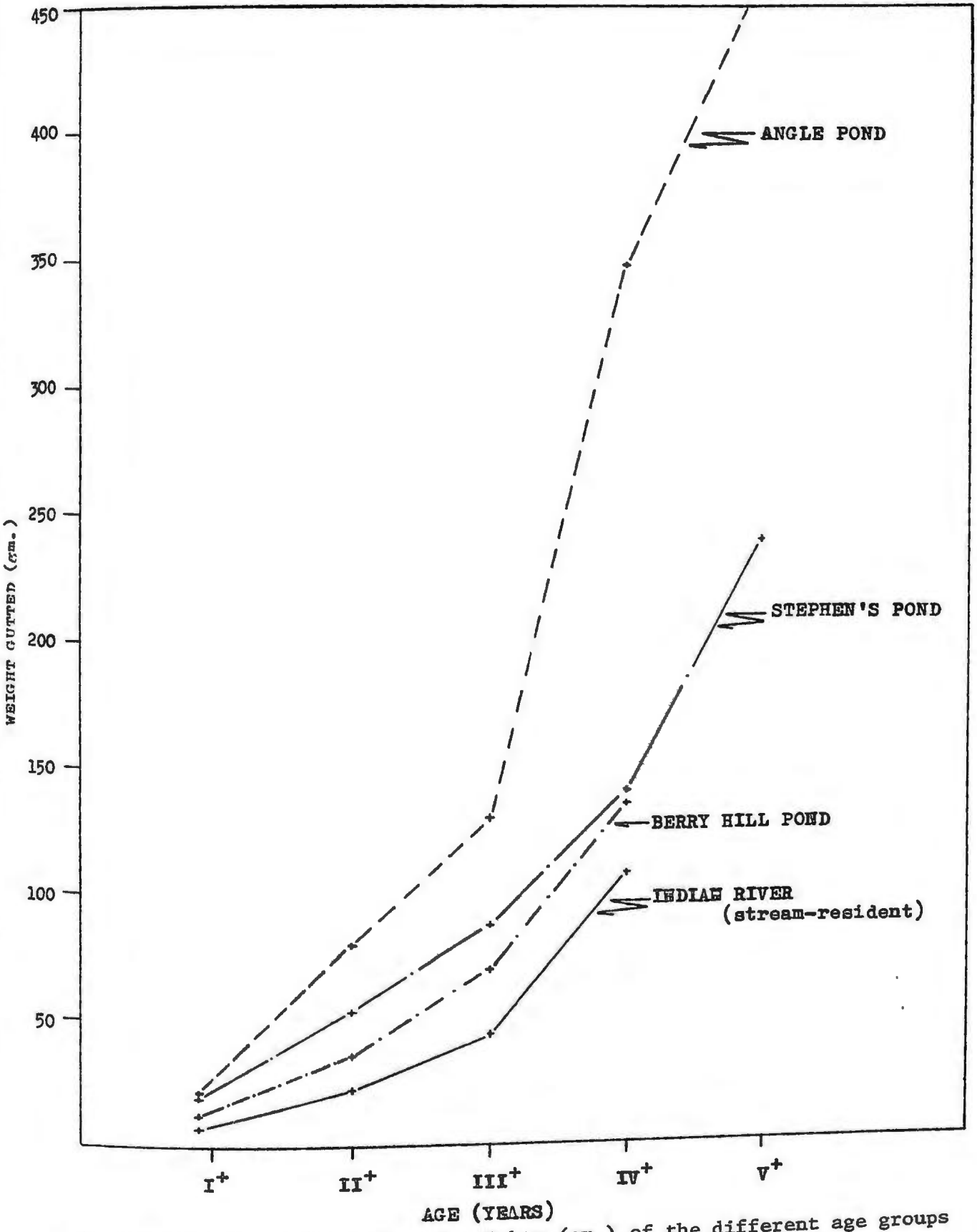


FIGURE VI: 8a. Average gutted weights (gm.) of the different age groups of speckled trout from various localities.

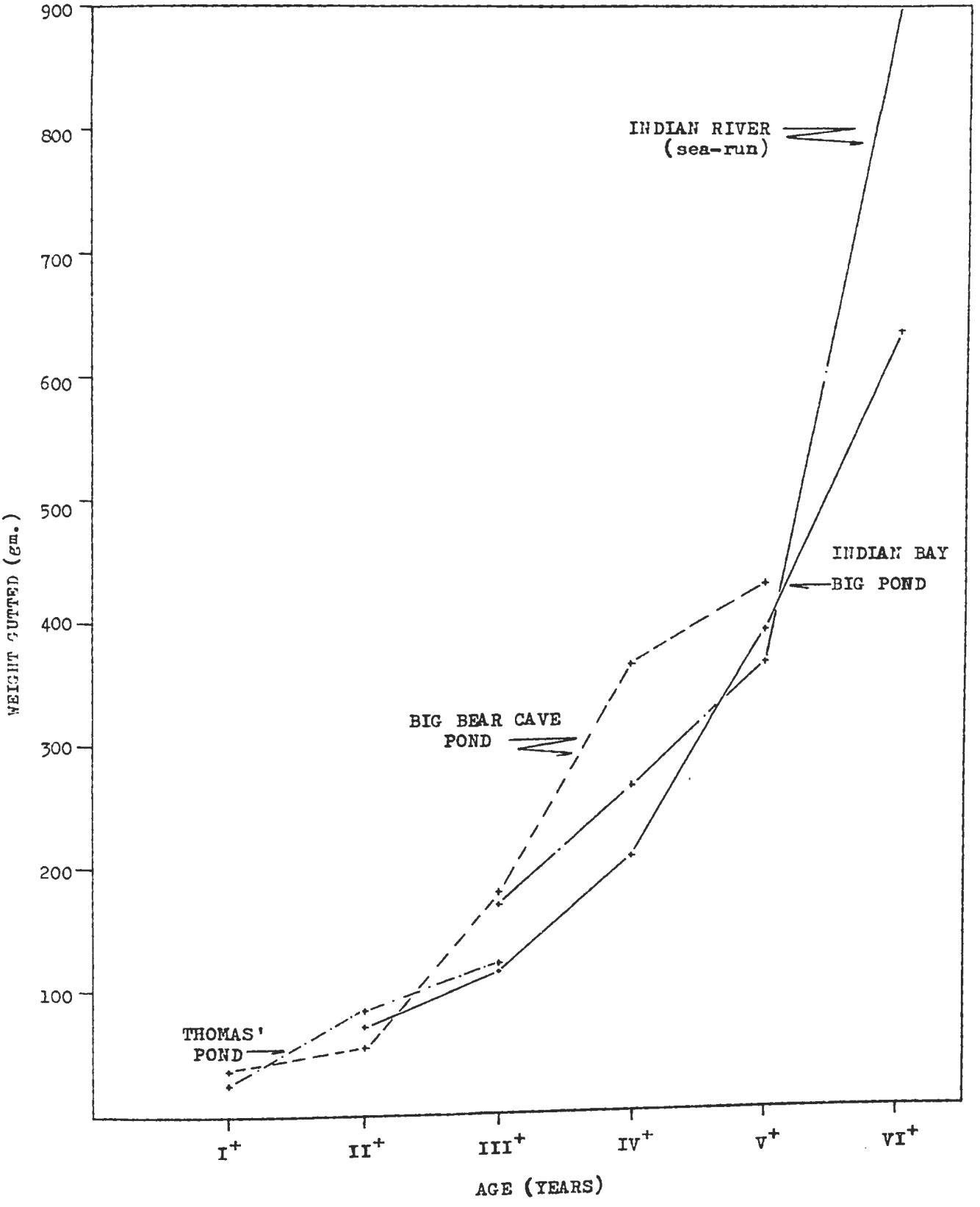


FIGURE VI: 8b. Average gutted weights (gm.) of the different age groups of speckled trout from various localities.

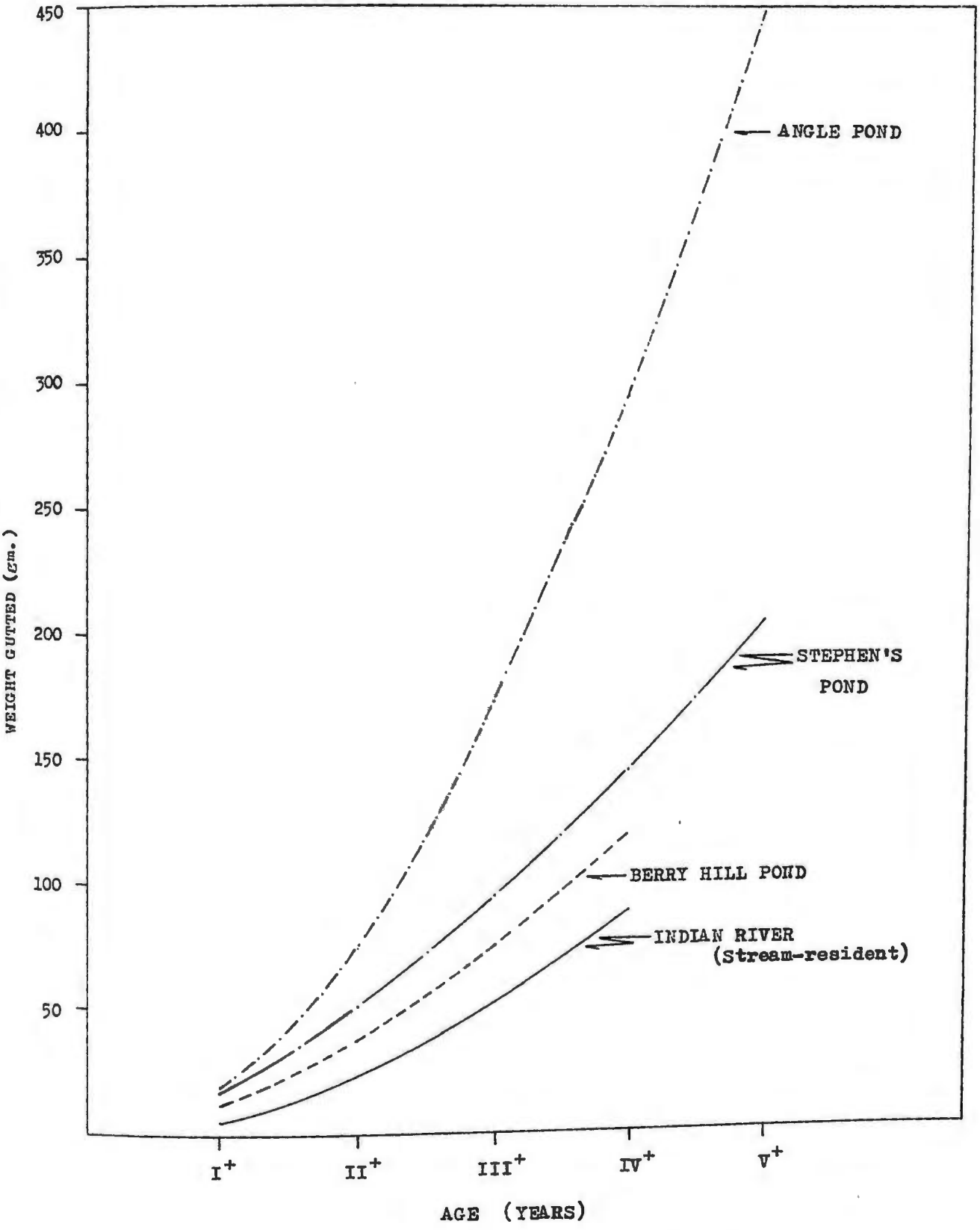


FIGURE VI: 9a. Calculated average gutted weights (gm.) of the different age groups of speckled trout from various localities.

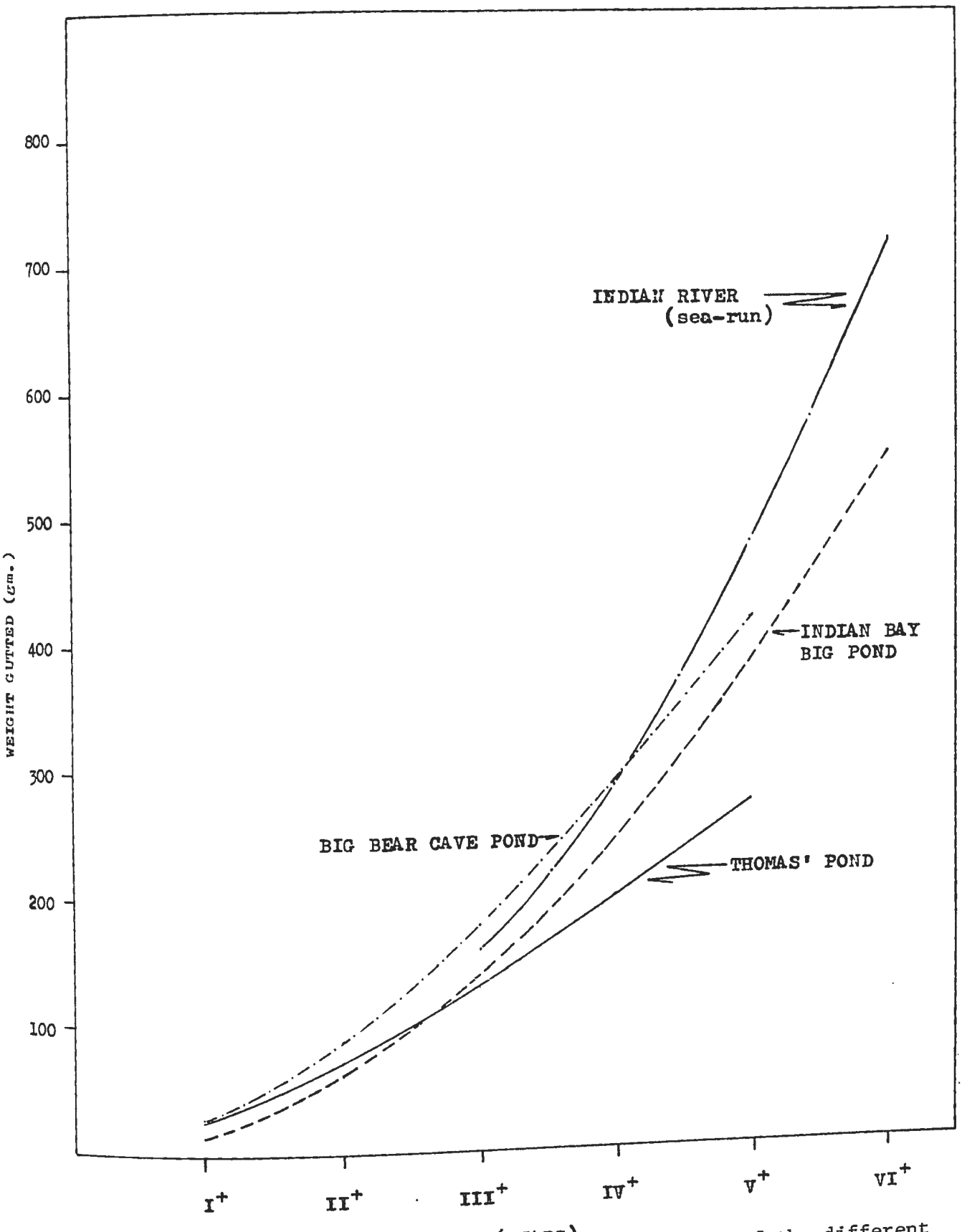


FIGURE VI: 9b. Calculated average gutted weights (gm.) of the different age groups of speckled trout from various localities.

Calculated age-weight gutted relationships for sexes separated and combined are given in Table 10 Appendix II, with corresponding standard errors of estimate.

To compare growth in weight between sexes, the calculated whole weights for sexes separated given in Table 7 Appendix II were used. Figures VI: 10 (a - c) show that males generally have a somewhat faster growth rate, at least in later years. It is noted that in both Big Bear Cave Pond and Angle Pond males are growing faster throughout the life span. Only Stephens' Pond shows females growing faster than males in later years and as already stated, this is probably due to differential angling mortality of faster growing males.

D. Length-Weight Relationship

1. General Considerations

The mathematical relationship between length and weight of fishes has been attempted with more or less success as to the approximate fitting of calculated and empirical values ever since Spencer's (1871) statement of the cube law. Most of the early attempts were simply expansions of Spencer's proposition and assumed both specific gravity and form remained constant throughout life. If this assumption was true, it follows that weight would be proportional to the cube of the length, giving:

$W \propto L^3$ or $W = a L^n$, where a is a constant of proportionality.

However as form and specific gravity do not remain constant throughout life, the cube law does not hold. A more satisfactory expression of the relationship is: $W = aL^n$ or expressed logarithmically:

$\log W = n \log L + \log a$, where a and n are empirical constants determined by computation following Rounsefell and Everhart (1953). The value

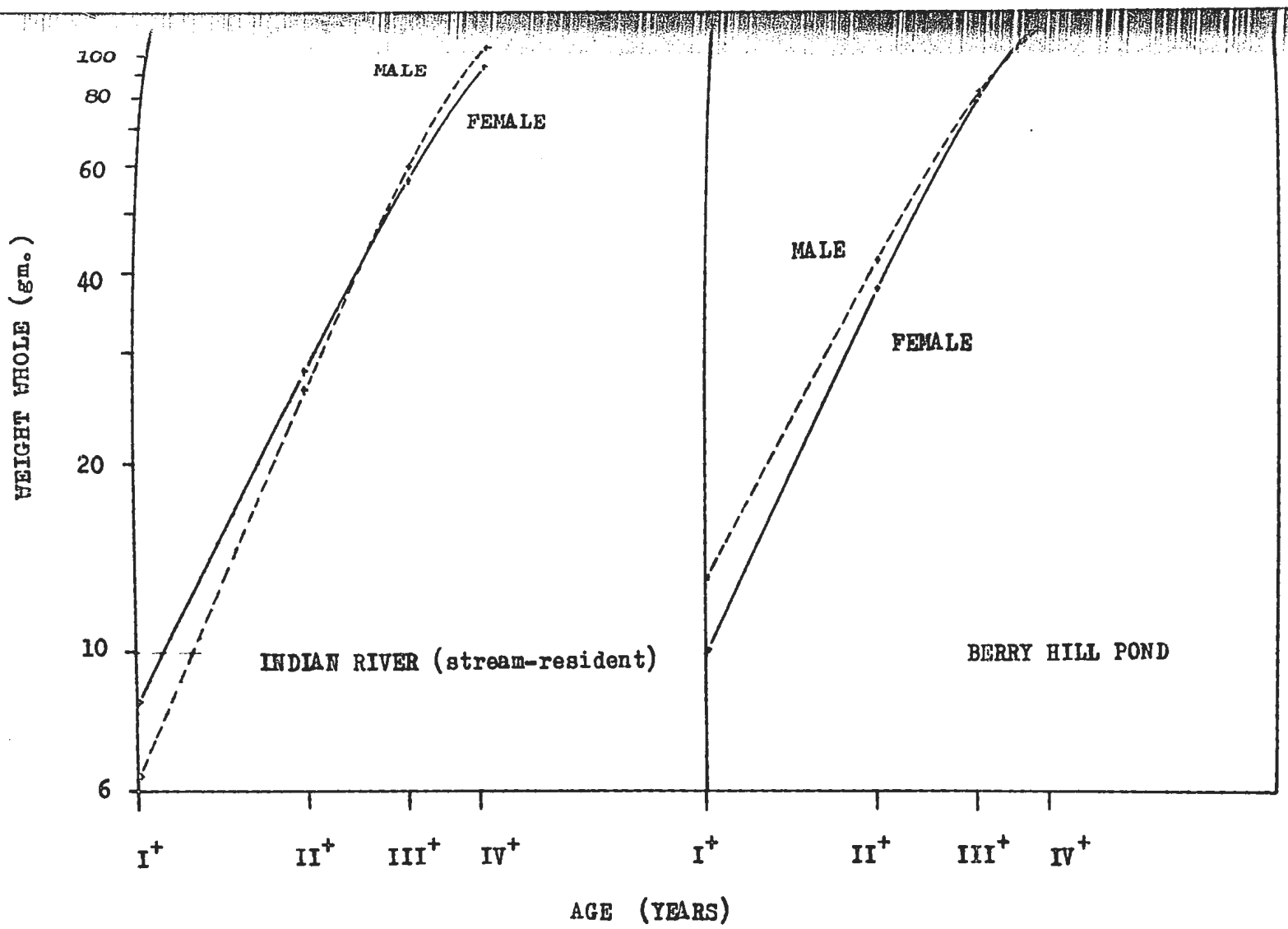


FIGURE VI: 10a. Calculated average whole weights (gm.) of the different age groups of male and female speckled trout.

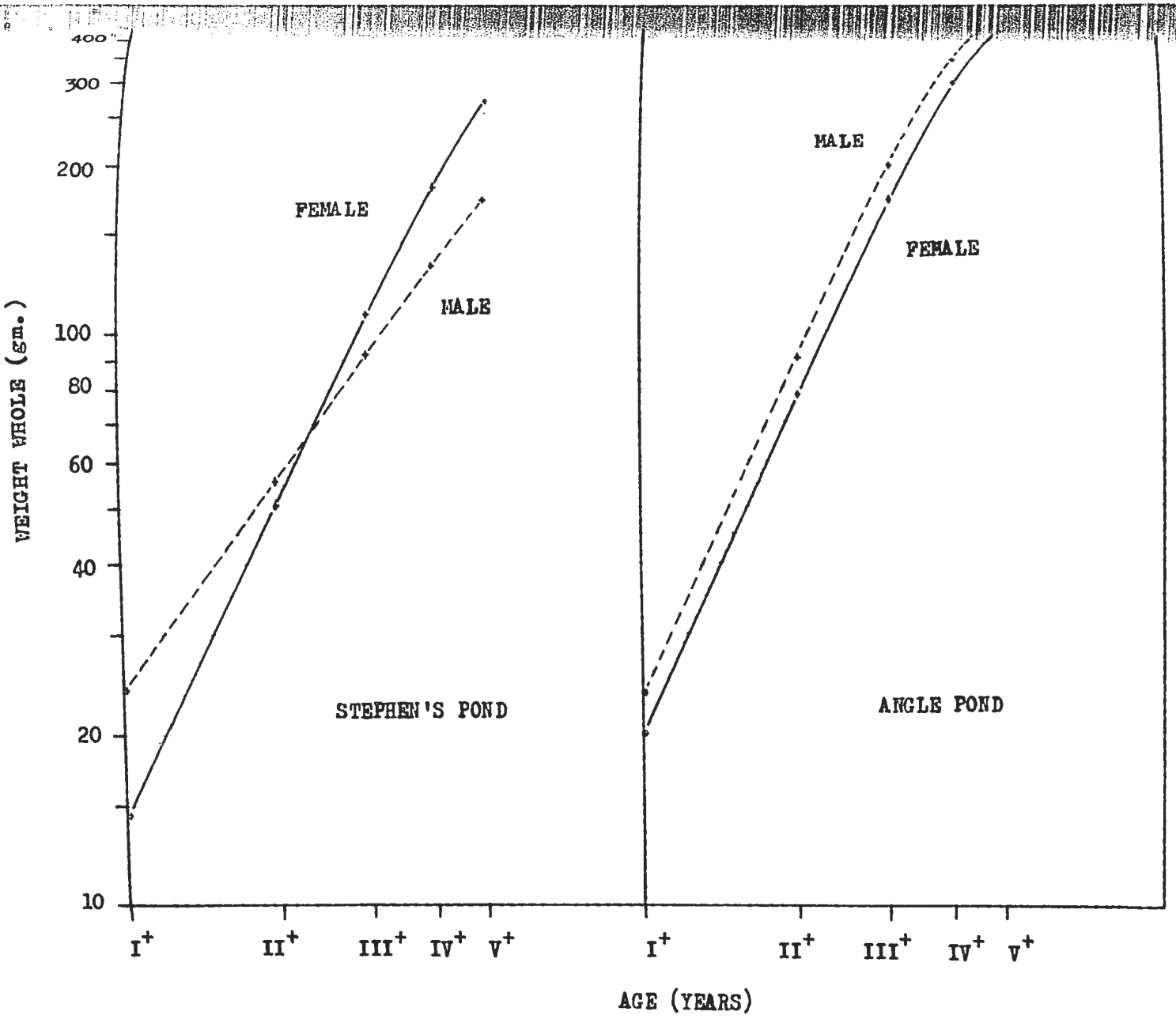


FIGURE VI: 10b. Calculated average whole weights (gm.) of the different age groups of male and female speckled trout.

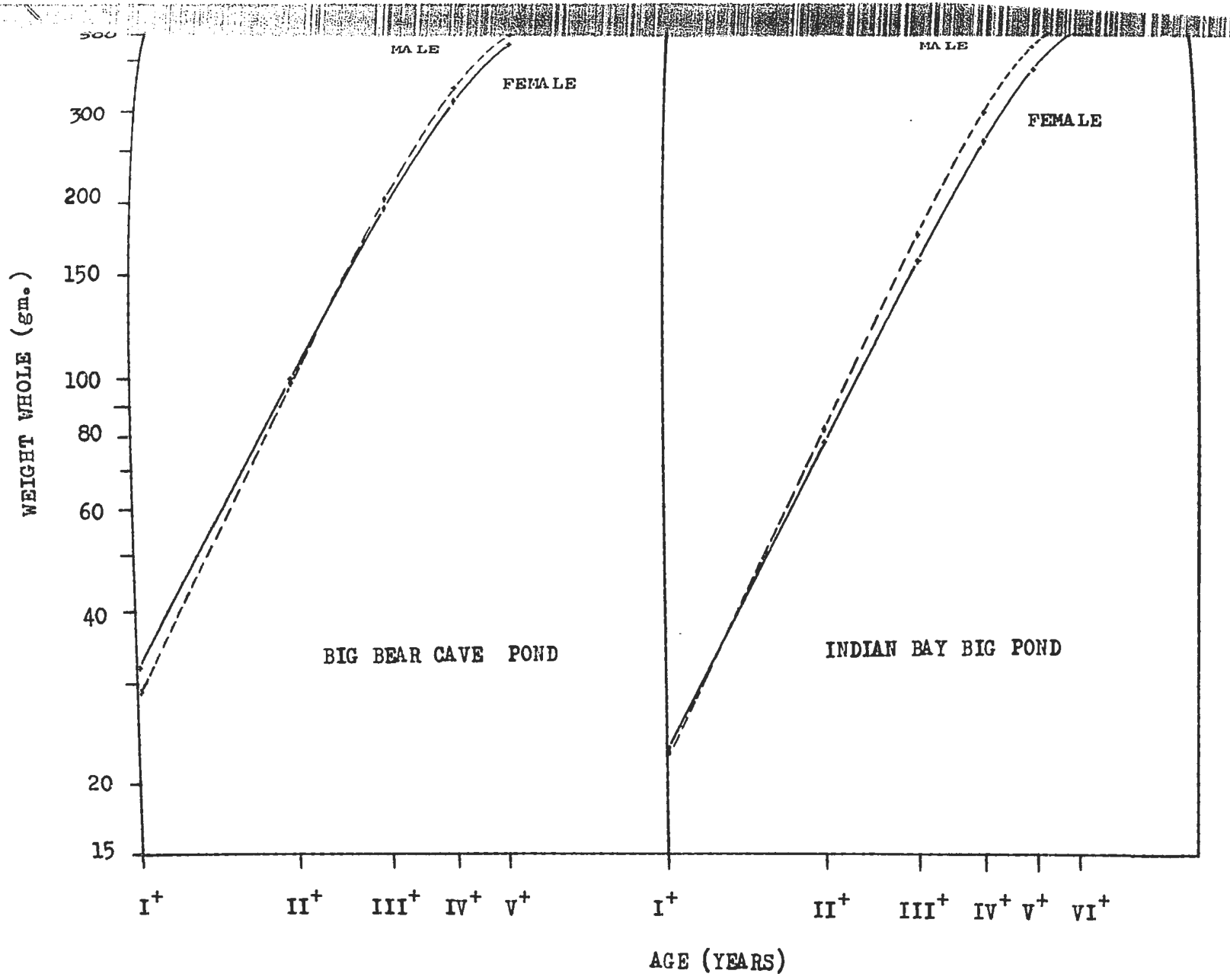


FIGURE VI: 10c. Calculated average whole weights (gm.) of the different age groups of male and female speckled trout.

of n usually lies between 2.5 and 4.0 (Hile, 1936 and Martin, 1949). For an ideal fish maintaining the same form n = 3, and this has only occasionally been observed (Allen, 1938).

The value of n not only rarely equals 3 but it has been found that the value of n may vary for fish from different localities, of different sexes, and of different growth stanzas; however, it is often constant for fish similar in these respects. Le Cren (1951) suggests the length-weight relationship may thus be a way of differentiating small taxonomic units, like any other morphometric relationship.

Therefore, the length-weight relationship besides providing a means of calculating weight from length, and a direct way of converting logarithmic growth rates calculated for lengths into growth rates based on weight may also give indications of taxonomic differences and events in the life history such as the onset of sexual maturity.

It is important however that the data should not have been subjected to any selection for weight against length. For example, gill nets may select the fatter among short trout or the thinner among long trout, and thereby lower the value of n even though the means of length and weight may be unaffected (Le Cren, 1951).

In fishery biology the presentation of length-weight data has become stereotyped so that confused thinking on its aims, methods employed, and results have resulted (Le Cren, 1951). Le Cren points out that the analysis of length-weight data has been directed towards two rather different ends. First, it has been used to describe mathematically the relationship and to make it possible to convert length data into weight data. Secondly, it has been used to describe the variation from the expected weight for length of fish as indication of condition, or degree of robustness, etc.

In this study the term length-weight relationship is applied strictly to the first category, and the term condition is applied to the second category and is discussed separately.

The length-weight relationship was calculated by arranging the fork length data into 2.0 cm. intervals and calculating the mean whole weight in grams for each interval. The log regression was calculated for the variables fork length (class mark) in cm. and whole weight in grams. The empirical length-weight whole data are shown in Table 11 Appendix II.

Table 12 Appendix II lists the calculated length-weight whole relationships for sexes separated and combined, and the corresponding standard errors of estimate.

The values of the exponent n range from approximately 2.5 to 3.3. These compare with those found by Cooper (1961) who reported a range from 2.63 to 3.37. Cooper and Benson (1951) report an n value of 2.94 for Pigeon River, Michigan and Allen (1956) gives 3.11 as the exponent for a population of a Wyoming beaver pond. These values indicate that the cube law relationship does not strictly hold true.

Table 13 Appendix II gives the calculated whole weights obtained from the above mentioned length-weight relationships and are expressed in graphic form in Figures VI: 11(a-b). Unlike growth per se, weight as a function of length does not bear a direct positive relationship with the habitat size. It can be seen that the ratio of weight to length increases in favor of weight as the habitat changes from stream to small pond (Indian River, Berry Hill Pond, and Stephens' Pond), but from small pond to lake (Angle Pond, Thomas' Pond, Big Bear Cave Pond, and Indian Bay Big Pond) the ratio of weight to length decreases. That is in simplest terms, the ratio of weight to length reaches a

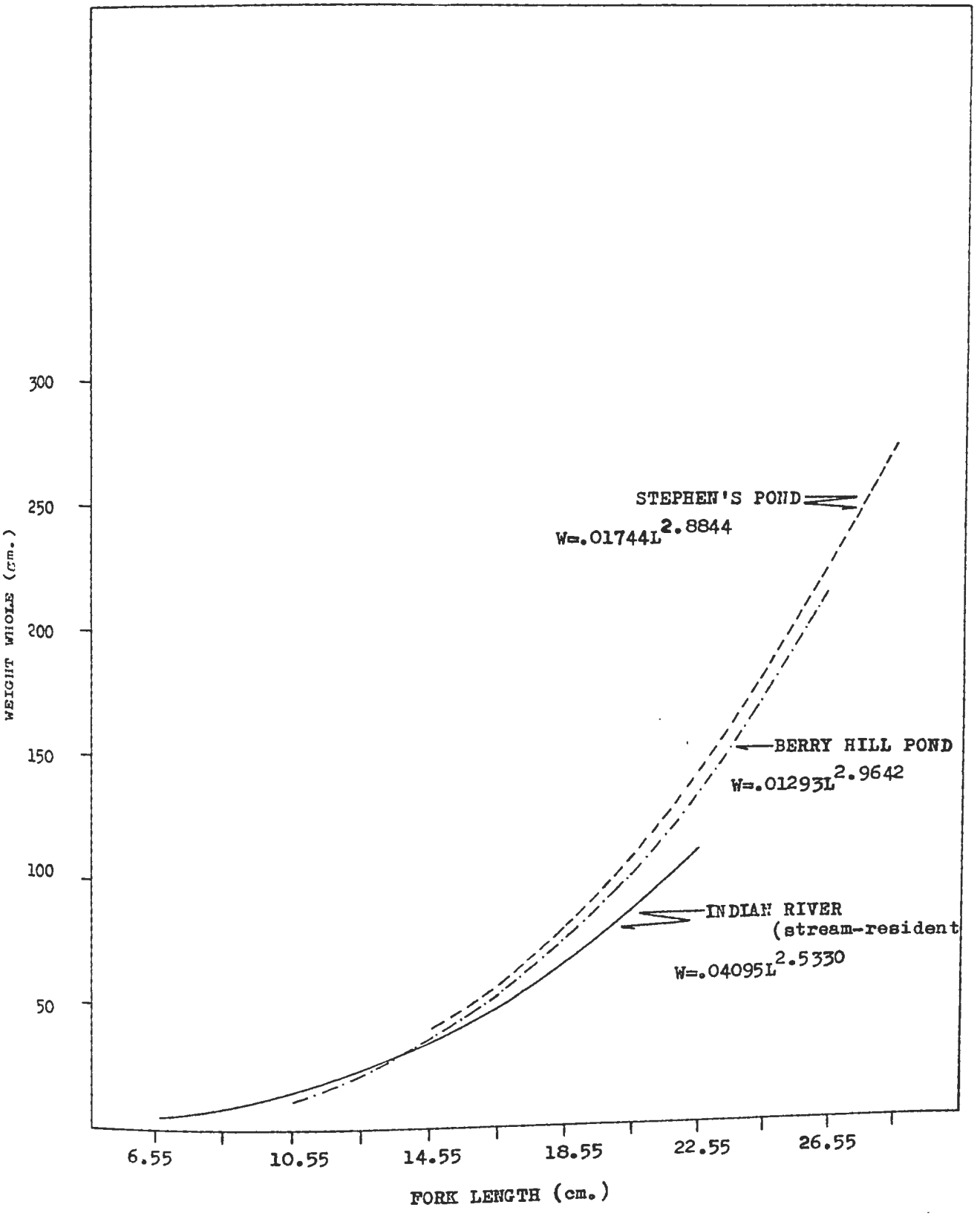


FIGURE VI: 11a. Calculated length-weight whole relationships of speckled trout from various localities.

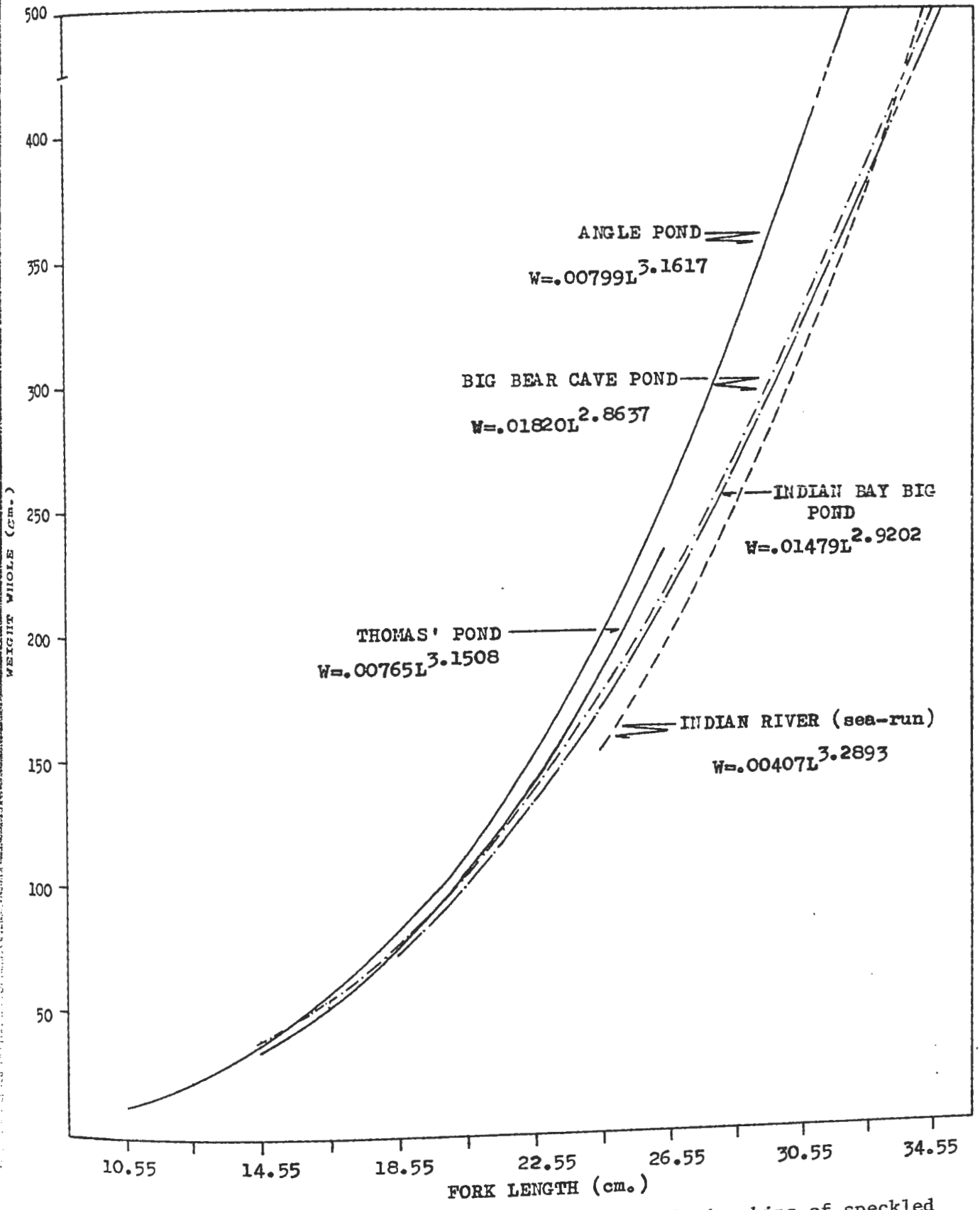


FIGURE VI: 11b. Calculated length-weight whole relationships of speckled trout from various localities.

maximum or optimum and then decreases as the habitat progresses from stream to lake.

The suggested reasons for such marked changes in the length-weight relationship between habitats are environmental. The trout in streams are undoubtedly subjected to colder water temperatures, overcrowded conditions and low productivity. In fact, it has been shown that stream trout usually depend heavily on terrestrial insect food in summer when aquatic food is scarce (Hoover, 1939).

With an increase in habitat size to ponds there is a corresponding increase in space and in productivity. Brown (1946) suggests the degree of robustness of brown trout is directly proportional to the amount of storage fat present. The deposition of storage fat can only occur after maintenance requirements are met; thus in areas where food is not such a limiting factor, fat deposition occurs, and increases in weight occur as a result.

In lakes, lower productivity, especially with regard to larger food organisms, again causes a decrease in the potential weight for a given length. Thus growth in length continues but growth in weight which is a reflection of deposition of storage fat does not occur to its full potential.

The fact that the sea-trout show a smaller weight per given length than any of the other fish is interesting. Although fresh run sea trout are relatively heavy per given length as a rule, the fact that they feed very little or not at all in fresh water (White, 1940) results in a significant loss of weight after being in fresh water for any length of time (White, 1942; and Wilder, 1952). The Indian River sample was taken in August and undoubtedly the fish had been in fresh water for some time. No food was found in any of the stomachs.

Length-weight gutted relationships were also calculated to remove the variables introduced when whole weights are used.

Le Cren (1951) suggests, at least for the yellow perch, that although there is some individual variation in the gonad : body weight ratio, it tends to remain constant at any one season for all sizes of fish of the same sex and maturity. He also suggests that stomach contents weigh up to 2% of the body weight in summer.

The calculated length-weight gutted relationships are given in Table 14 Appendix II with their corresponding standard errors of estimate. The relationships were calculated from empirical data given in Table 15 Appendix II.

Figures VI: 12(a-b), based on calculated gutted weights listed in Table 16 Appendix II, are perhaps more illustrative of the overall situation regarding length-weight relationships.

Figure VI: 12a shows little relative difference from the length-weight whole relationships of Figure VI: 11a. However, Figure VI: 12b shows at least one instance of a relative difference from the length-weight whole relationships of Figure VI: 11b. It is noted that the length-weight gutted relationship for Indian River sea-trout is shifted relatively less to the right of the length-weight whole relationship than any of the other localities, indicating that lack of stomach contents (food) and perhaps intestinal fat reserves are responsible.

2. Seasonal Variation in the Relationship

Since sampling was carried out in Stephen's Pond throughout the summer and early fall of 1965, it affords an opportunity to observe seasonal changes in the length-weight relationship. The length-weight relationships for the

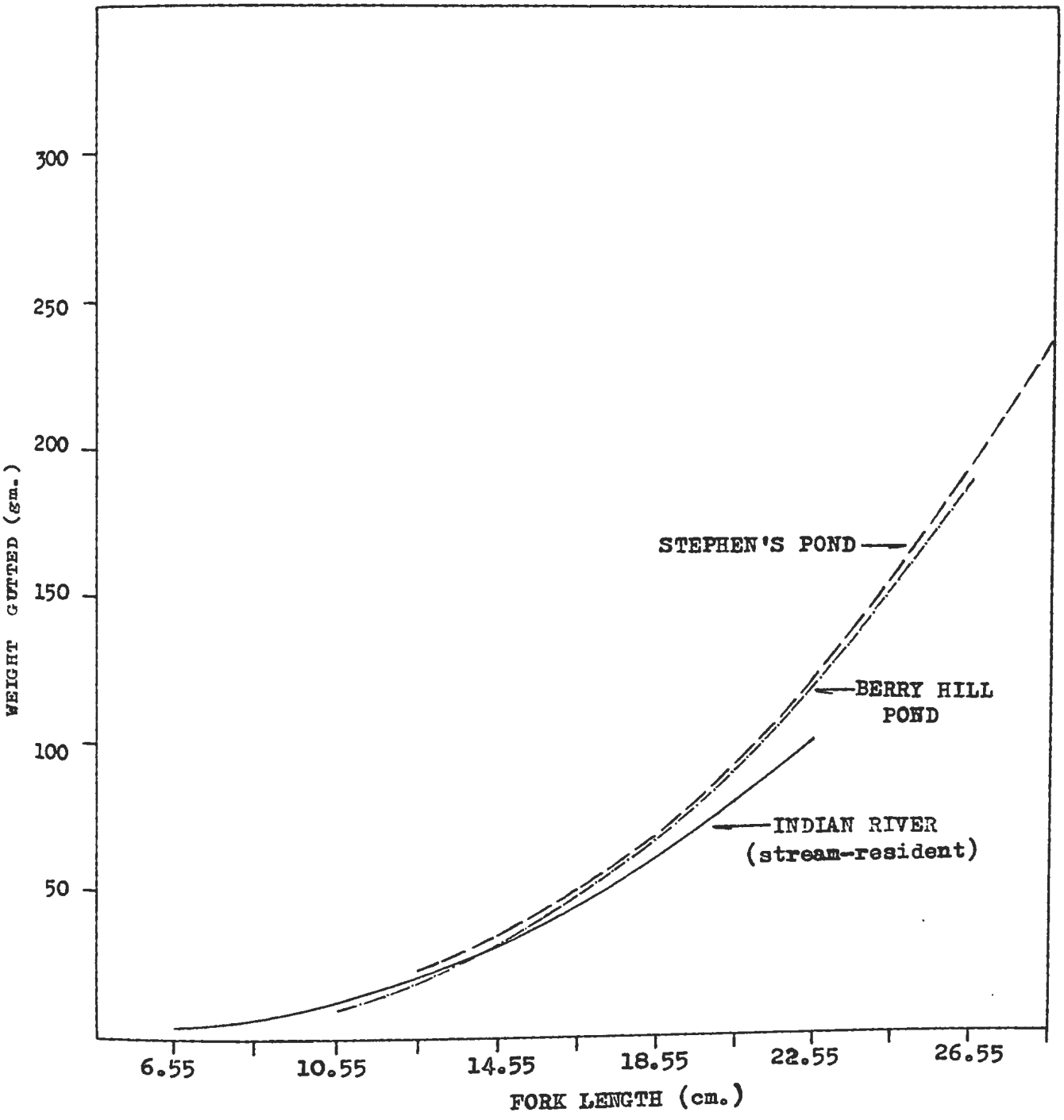


FIGURE VI: 12a. Calculated length-weight gutted relationships of speckled trout of various localities.

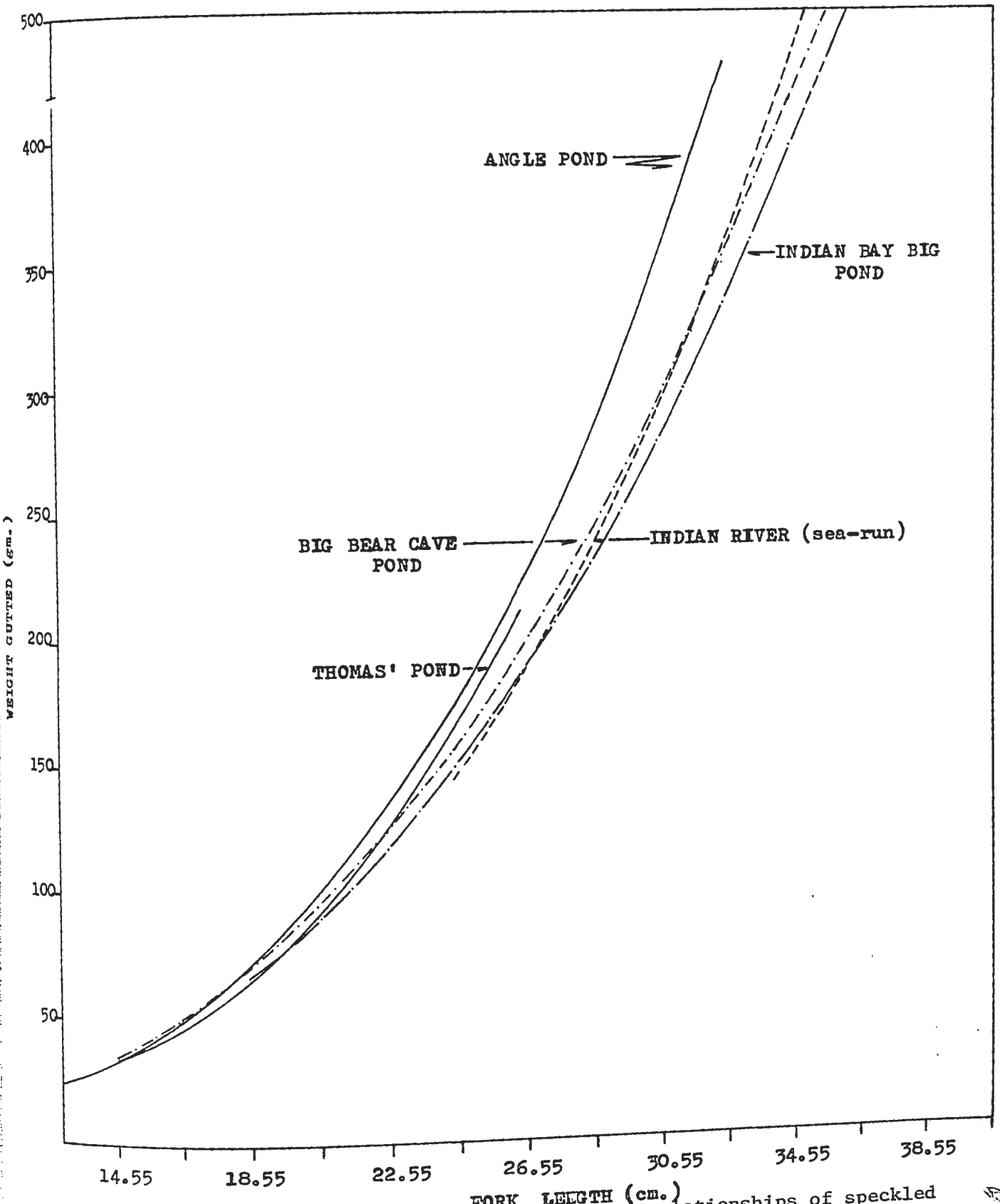


FIGURE VI: 12b. Calculated length-weight gutted relationships of speckled trout from various localities.

months of June, July, and September are shown graphically in Figure VI: 13. There is a noticeable shift to the left with passage from spring into fall, indicating that the fish are increasing in weight per unit length during the season, or simply, fish of the same length are heavier than fish of a similar length earlier in the season.

Numerous authors have reported such a seasonal change (Hazzard, 1932; Went and Frost, 1942; Cooper and Benson, 1951; Cooper, 1953; and Rupp, 1955) in the length-weight relationship and in addition Went and Frost (1942) and Cooper (1953) show a correlation between growth and a change in the relationship. Periods of rapid growth are thought to be associated with increase in the weight per unit length, whereas slow growth is associated with a decreased weight per unit length. The increase in weight per unit length in early summer is suggested to be the result of rising temperatures and increased food intake and feeding efficiency. The increase in autumn, however, is said to be the result of maturation of the gonads which masks the, now, other less influencial environmental factors.

3. Variation Between the Sexes

Several authors have reported on the variation of the length-weight relationship between the sexes.

Menzies (1924) reports that mature male Atlantic salmon are invariably lighter than female fish of the same length. Hoar (1939) however, reports that immature males (parr) are heavier at a given length than females.

Hile (1936) and Marr (1943) however, point out that there are no consistent significant differences between the sexes for ciscoes and chum salmon respectively.

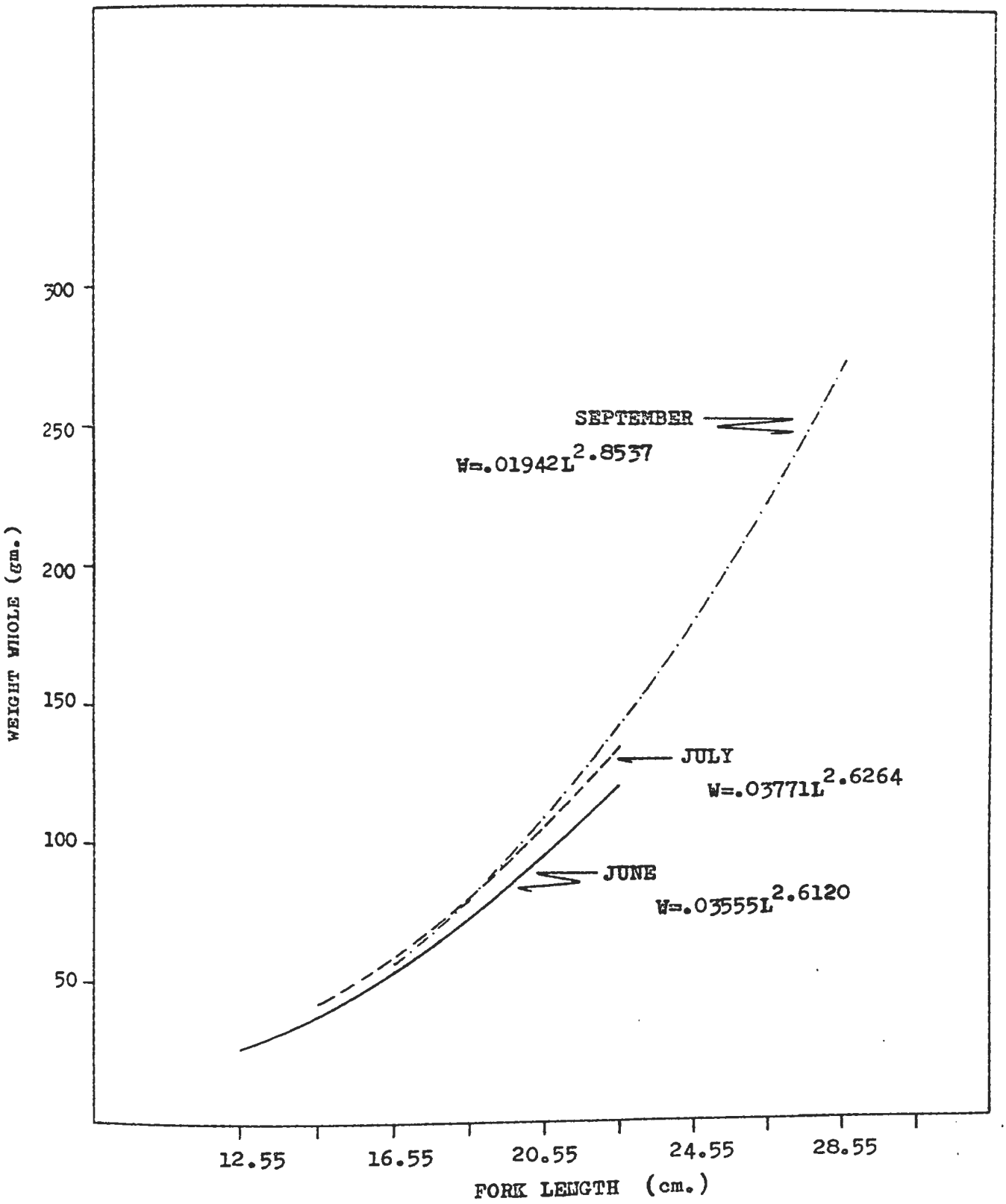


FIGURE VI: 13. Seasonal change in the calculated length-weight whole relationship of Stephens' Pond speckled trout.

In this study an attempt was made to determine if variation between the sexes existed by using gutted weights. Whole weights would have a tendency to over-accentuate any differences which would exist because of the influence of gonads, intestinal fat deposits, and perhaps stomach contents. A comparison of actual plumpness all round is dealt with in considering the index of condition in a later section.

Figures VI: 14(a-d) show the length-weight gutted relationships for the sexes separated using calculated gutted weights. Resident male brook trout taken at Big Bear Cave Pond, Berry Hill Pond, and Indian River are heavier than females over the entire range of lengths considered. At Thomas' Pond, Stephen's Pond, and Angle Pond the males are heavier than females of the same length only at the upper range of lengths; however, the difference may be more pronounced as these areas are heavily fished and the calculated values at the lower end of the length range could conceivably be influenced by differential removal of males at the upper range. Both Indian Bay Big Pond resident trout and Indian River sea-run trout show little difference with females perhaps a little heavier at the upper range of lengths. Without further elaboration, it would seem sufficient to say that, in general, males are perhaps heavier than females of the same length, at least at the upper end of the length range.

4. Relationship between the Exponent n and the Constant a.

The relationship between length and weight in trout has been shown to be adequately described by the parabolic equation $W = aL^n$, where a and n are empirically determined constants.

Whereas this relationship is of use in conversion from length to weight data, the use of these constants for definitive purposes is not

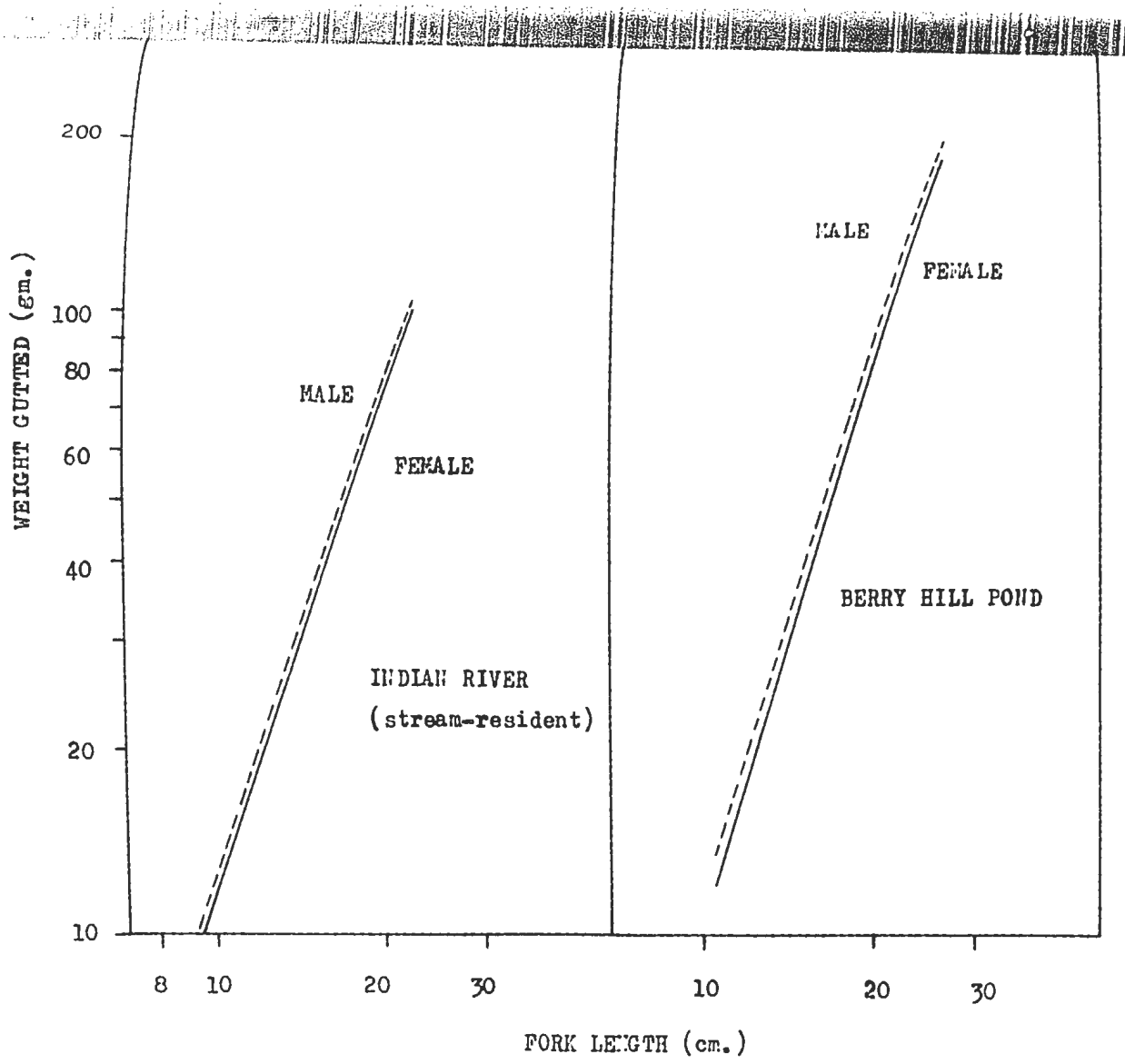


FIGURE VI: 14a. A comparison of the length-weight gutted relationships of male and female speckled trout.

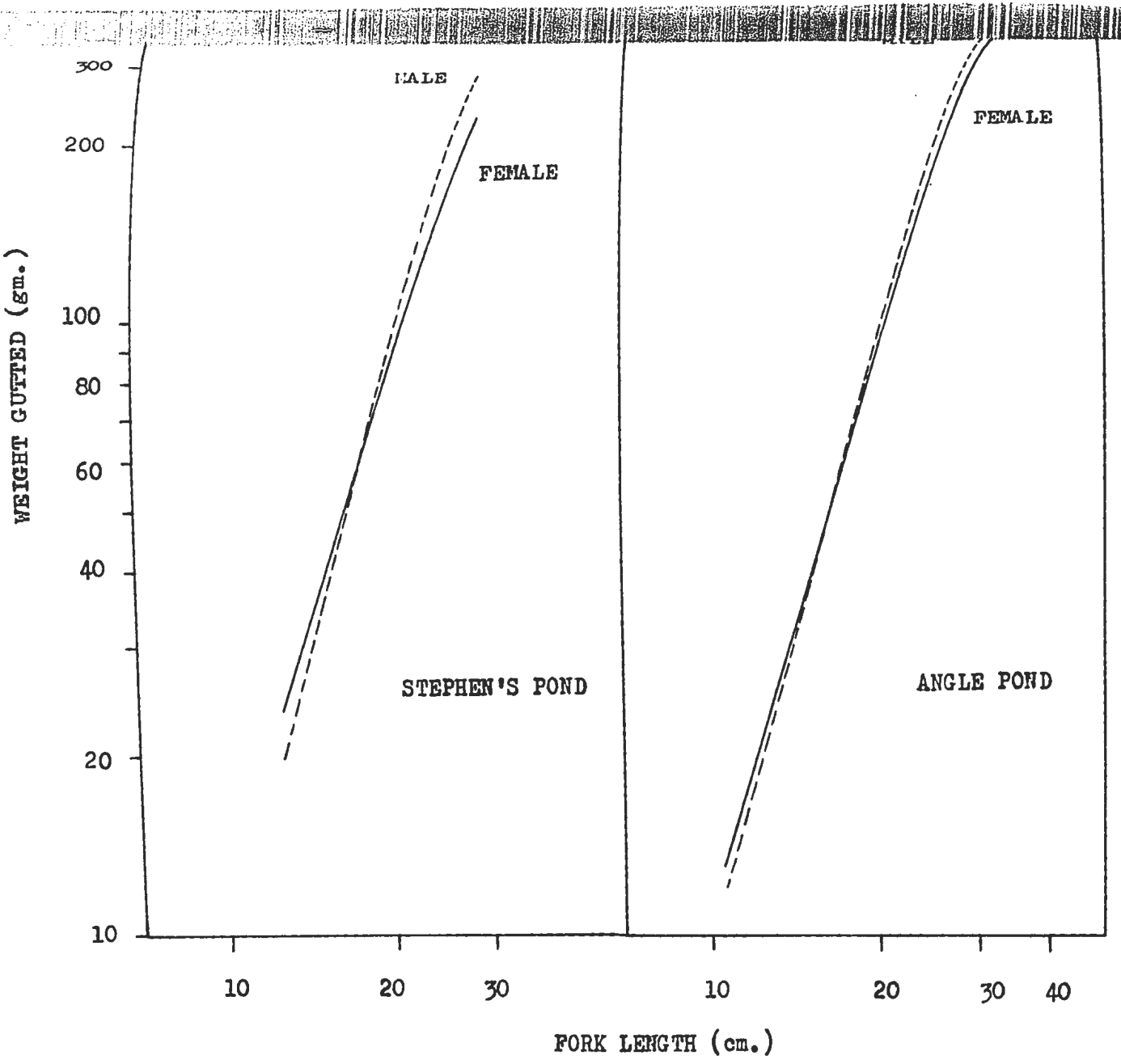


FIGURE VI: 14b. A comparison of the length-weight gutted relationships of male and female speckled trout.

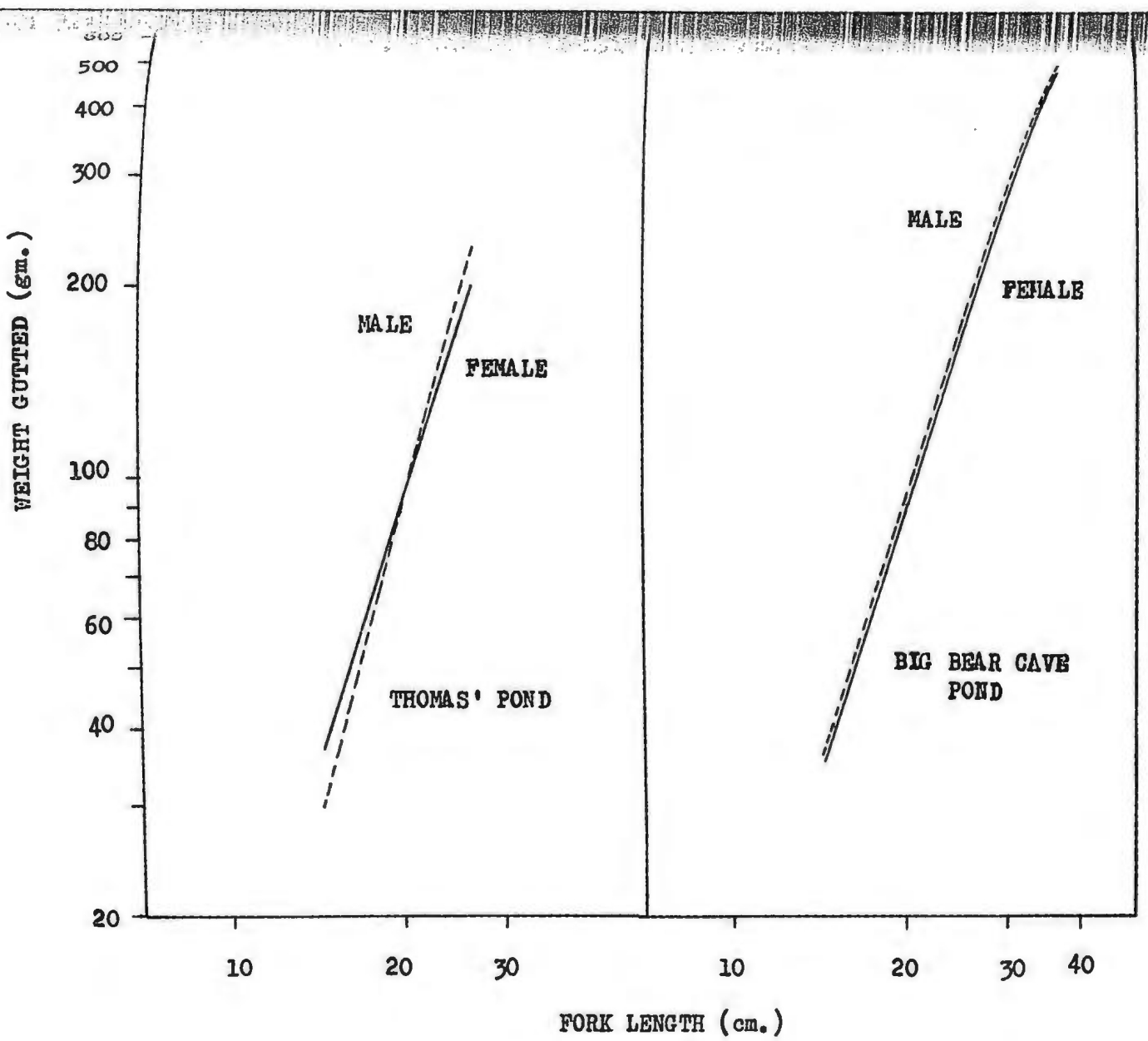


FIGURE VI: 14c. A comparison of the length-weight gutted relationships of male and female speckled trout.

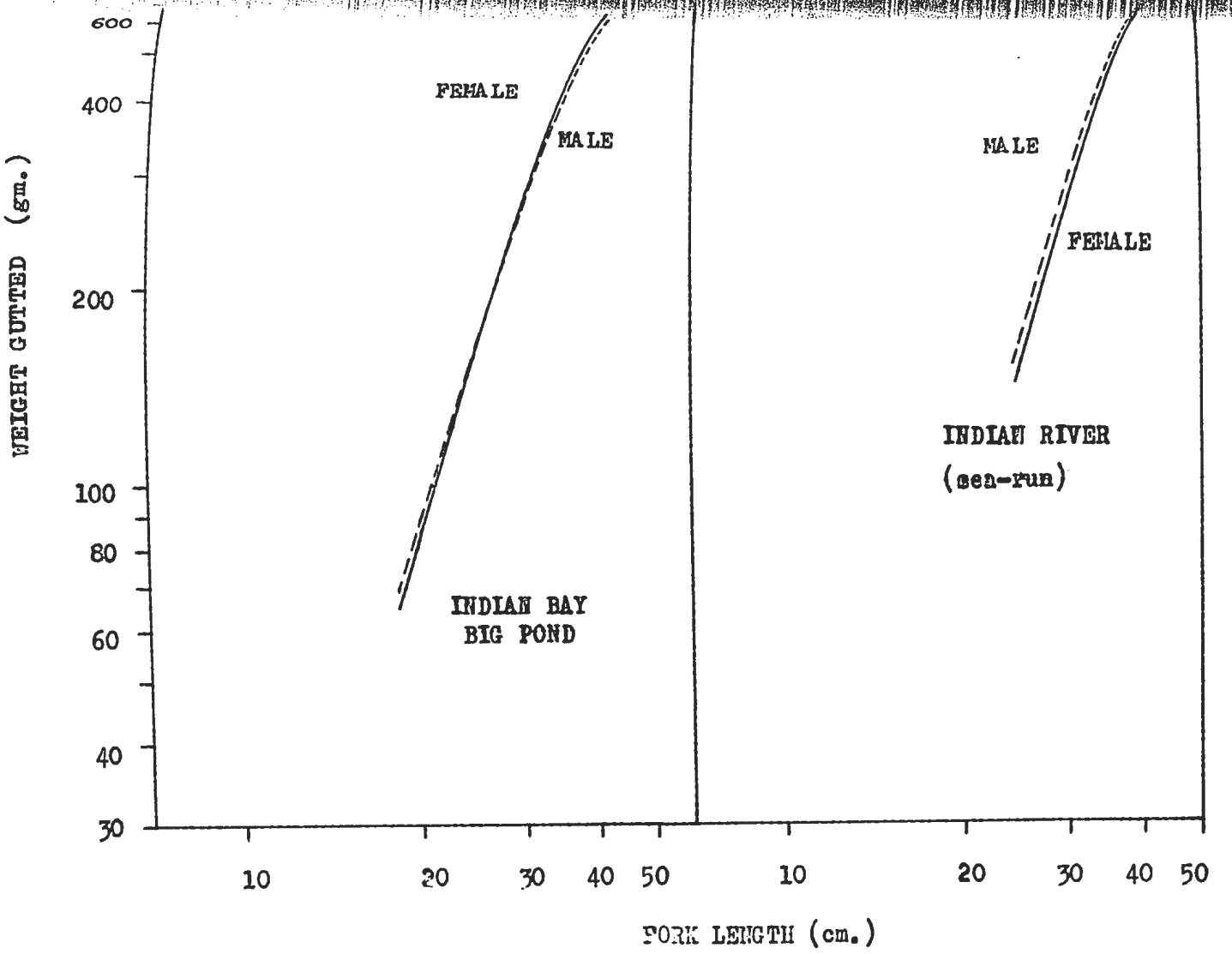


FIGURE VI: 14d. A comparison of the length-weight gutted relationships of male and female speckled trout.

generally favored because it has been shown that they are variable. Hile (1936) suggests that for ciscoes the exponent n is neither constant for species or populations. Le Cren (1951) reports different n values for various life history stages of the yellow perch, and Carlander (1950) and Cooper (1961 report similar variations in the value of n for speckled trout.

Cooper (1961) suggests it is not unusual for values of n to vary even within the same population and suggests variable environmental growth factors usually mask any genetic stability of the length-weight characteristics. Cooper used analysis of variance of the regression coefficients (n values) and found significant differences. The variance of n alone in the data was determined by computing the value of a from the composite of all groups. He now found slight differences in n were significant.

The hint that the constant a might be more than simply a proportionality constant was suggested as early as Heincke (1907) and Johnston (1914) who suggested it should be used as a definitive growth characteristic because of its variability. However, because of the wide acceptance of the cube law its importance was overlooked (Keys, 1928).

Keys (1928) has shown that when the cube law is assumed values of a are positively correlated with the weight; however, when the exponential form is used, a was found not to be correlated with weight.

Hile (1936) points out that a and n are negatively correlated, that is, values of a are such that an increase in the value of n results in a lower value of a and lower values of n result in higher values of a.

The values of a and n listed in Table 12 Appendix II are plotted graphically (Figure VI: 15) and the scatter diagram was easily fitted by a straight line. The equation of the line was of the form $\text{Log } a = zn + \log T$ (1)

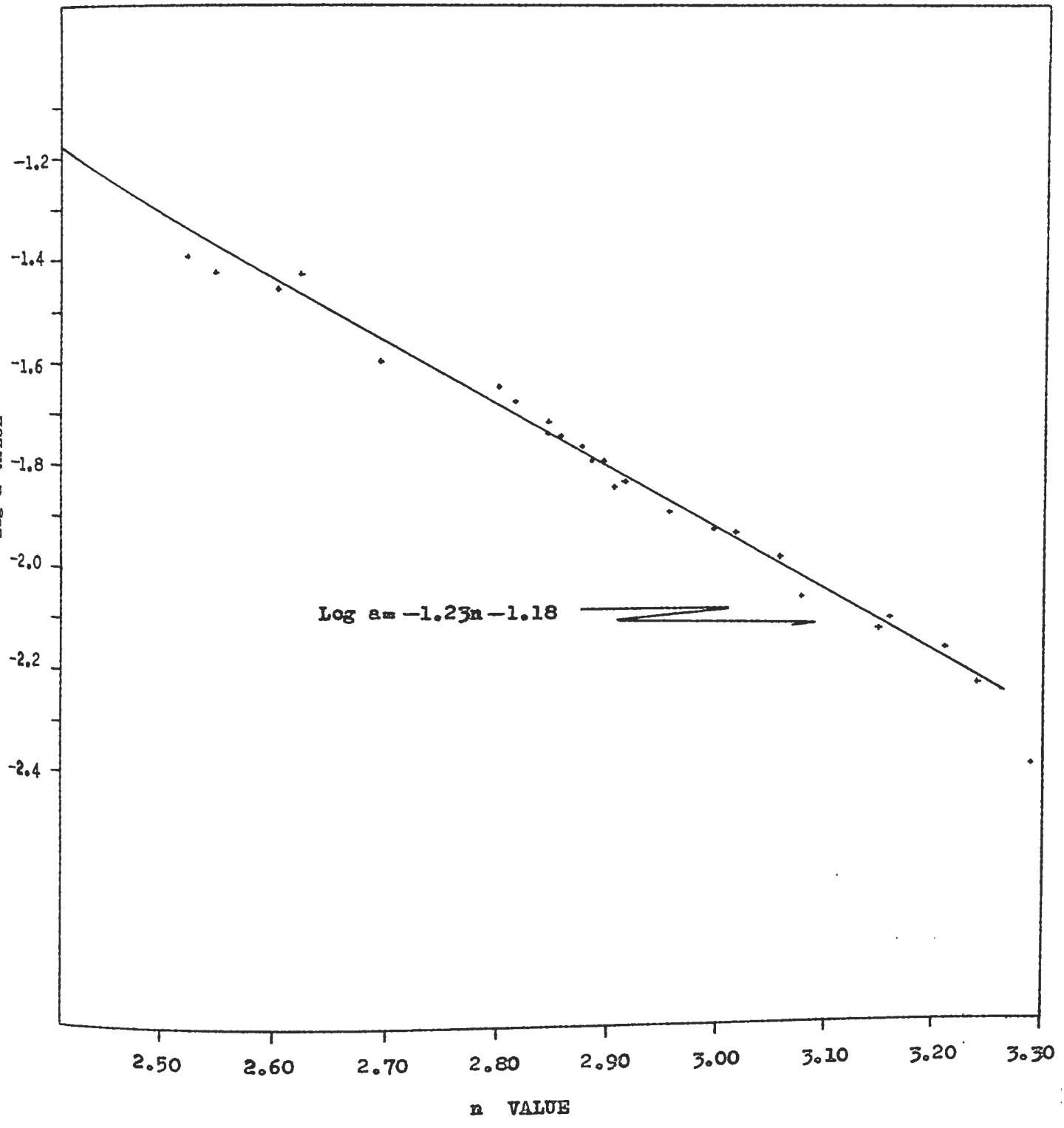


FIGURE VI: 15. The relationship between a and n, the EMPIRICALLY DETERMINED CONSTANTS OF THE LENGTH-WEIGHT WHOLE RELATIONSHIPS OF SPECKLED TROUT.

where z is the slope, and log T the intercept. From Figure VI: 15, log a = - 1.23 n - 1.18 (2) removing logs from equation (1) yields:

$$a = T_e^{zn} \qquad (3)$$

From Figure VI: 15, $a = 0.0661_e^{-1.23n}$ (4)

Since $W = aL^n$, substituting equation (4) yields: $W = T_e^{zn}L^n$ (5)

Substituting equation (4) into (5) yields: $W = 0.0661_e^{-1.23n}L^n$ (6).

Therefore we can now say $0.0661_e^{-1.23}$ is a species constant for speckled trout and that equation (6) is the best equation describing the length-weight relationship for speckled trout in Newfoundland waters.

This hypothesis would seem reasonable when one considers that there are biological upper and lower limits for surface-volume relations and a minimum and maximum weight limit for a given length seems reasonable in light of this fact.

It is perhaps unwise to attach too much biological significance to this new constant because as we have already seen, the relationship is at best weakly genetic in nature, and most likely strongly influenced environmentally.

E. Condition

Le Cren (1951) states, "Individual variations from the general length-weight relationship have usually been considered more interesting than the length-weight relationship itself, and have been frequently studied under the general name of condition."

Condition is defined as the degree of well-being, relative robustness, plumpness, or fatness. It is analysed by means of a condition factor, coefficient of condition, ponderal index, etc., with the objective of expressing the condition of the fish in numerical terms.

Besides being used to express the degree of well-being, condition factors have also been used as an addition to age and growth studies, and is often used to indicate the suitability of an environment, and to measure the effects of environmental improvement, including stocking (Cooper and Benson, 1951). Condition has also been used to compare fish from one area with a general average for an entire region.

Calculation of the coefficient of condition is based on the cube law, hence $W = KL^3$ or K (condition coefficient) = W/L^3.

Hile (1948) summarized the problems involved in the standardization of fish measurements and the corresponding calculation of condition factors. Although this makes comparison of condition factors difficult between different workers, factors for conversion for many fish are now given in such works as Carlander (1950). However, the apparent confusion and disagreement between workers does not invalidate a study of the changes in condition due to season, sex, size, and locality when the same index of condition is used.

Lagler (1961) suggests that for ideal purposes a comparison of condition factors should be between fish of the same length, age, sex, and captured (as close as possible) on the same date. In reality, these conditions are matched as close as possible.

The condition factor used in this study is after Hile (1936), where:

$$K = \frac{W \times 10^5}{L^3}$$

where $\underline{W}$ is the whole weight in grams, $\underline{L}$ is the fork length in millimeters. and 10^5 is a constant which allows K to assume a value near unity.

The number of variables that can affect the value of K is considerable, and will be discussed under four main topics: (1) selection in sampling,

(2) changes with age or length, (3) variations between the sexes, and (4) environmental influences, such as food supply, parasitism, and short term seasonal changes.

1. Selection in Sampling

The effects of gill nets on the length-weight relationship as previously mentioned, also apply to computation of the condition factor (Farron, 1936; Deason and Hile, 1947).

Cooper and Benson (1951) suggest small numbers of fish may not be representative of the condition of the whole population due to inadequate or improper sampling. They recommend the use of statistical methods such as measures of central tendency and reliability for comparative studies of condition.

2. Variation of Condition with Length

Numerous authors have commented on the change in K values with increased length.

For example, Beckman (1945) found that for the bluegill, yellow perch, smallmouth black bass, and northern pike, the condition factor increased with increase in length, while the largemouth black bass, and rock bass showed a decrease with increased length in Michigan waters.

Fleever (1951) reports that K values decrease with increase in length for Utah cutthroat trout.

Belding (1936) and Hoar (1939) both report higher condition coefficients with increased length for Atlantic salmon parr.

Shetter and Leonard (1940) report that speckled trout in Hunt Creek, Michigan, show an increase in K value with increase in length. Cooper and

Benson (1951) however, report that speckled trout in Pigeon River, Michigan, show a decrease with increased length, thus indicating that the variance may possibly be due to some local environmental conditions.

Because K does not always function independent of length, Le Cren (1951) suggested a relative condition factor not based on the cube law, but on $W = aL^n$. To avoid confusion, he designated the new factor Kn where $Kn = W/aL^n$. This factor Kn could then be used for relative comparisons.

In this study, however, the author devised a type of condition factor, which like Le Cren's, is based on the exponential relationship rather than the cube law. It was found that this condition factor, which is designated Kc (because it is based on calculated data), is very useful in smoothing fluctuating data to give a trend.

Table 17 Appendix II lists both the condition factor K (based on the cube law) and Kc (based on the exponential form), and shows the variation with length for the various localities studied.

The data are then presented graphically in Figures VI: 16 (a-e). It is noticed that for speckled trout from the localities studied, the value of the condition factor may either increase or decrease with increase in length. Only Angle Pond and Thomas' Pond resident trout and Indian River sea-trout show a positive relationship, while trout from the other areas show a negative relationship with increase in length.

Shetter and Leonard (1940) suggest the onset of sexual maturity in larger trout is partly responsible for an increase in condition with increase in length. This seems doubtful however.

Le Cren (1951) suggests that since fish do not obey the cube law exactly, length and any factor correlated with it will affect the condition-

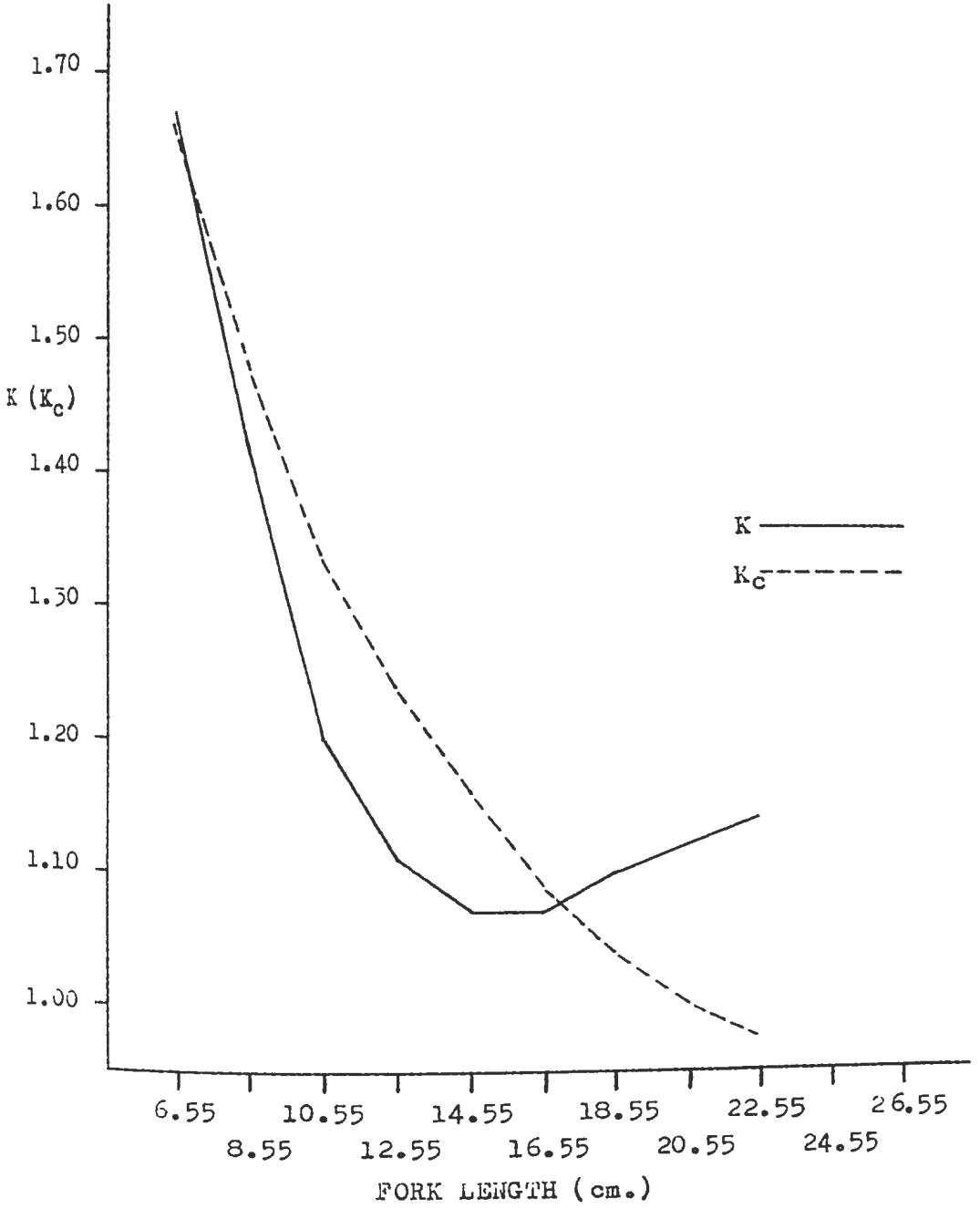
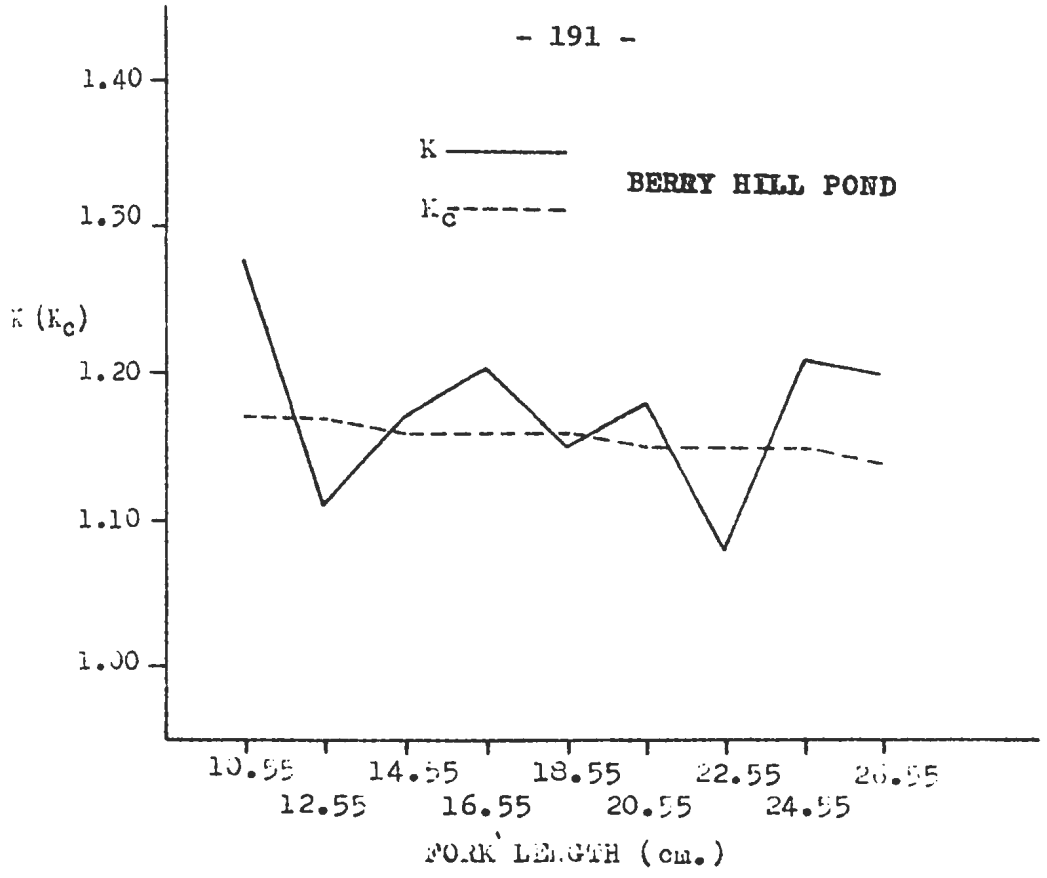


FIGURE VI: 16a. The variation of the condition factors K(Kc) with length for Indian River stream-resident speckled trout.



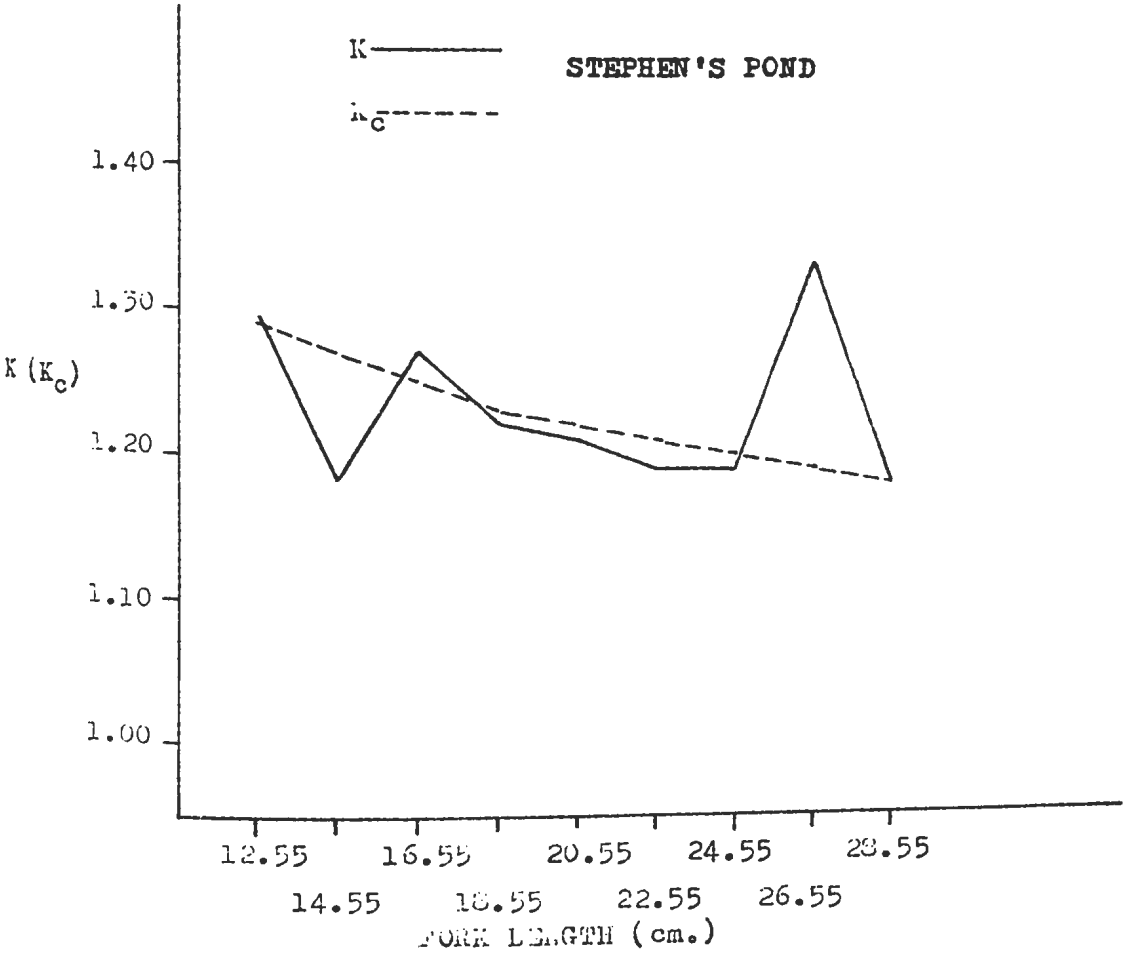


FIGURE VI: 16b. The variation of the condition factors K(Kc) with length for Berry Hill and Stephen's Ponds speckled trout.

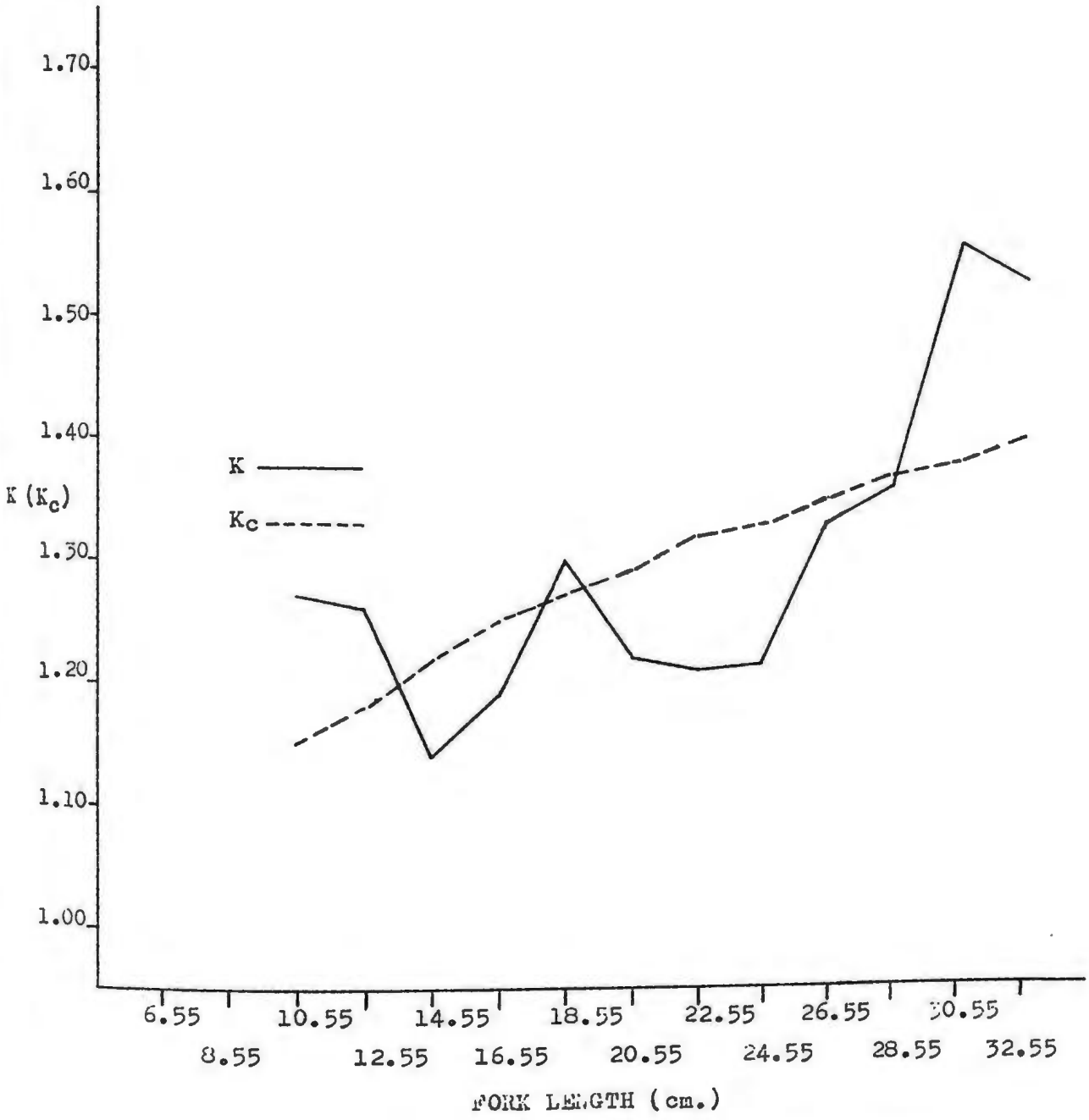
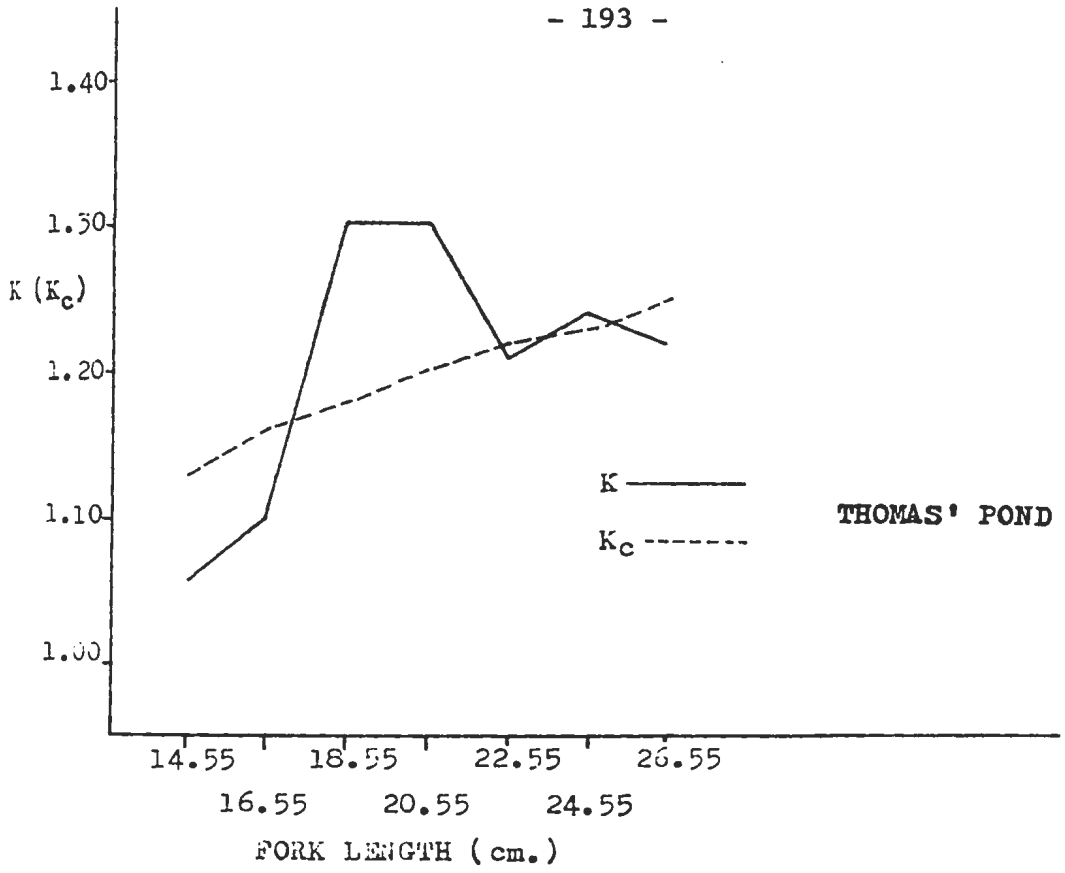


FIGURE VI: 16c. The variation of the condition factors K(Kc) with length for Angle Pond speckled trout.



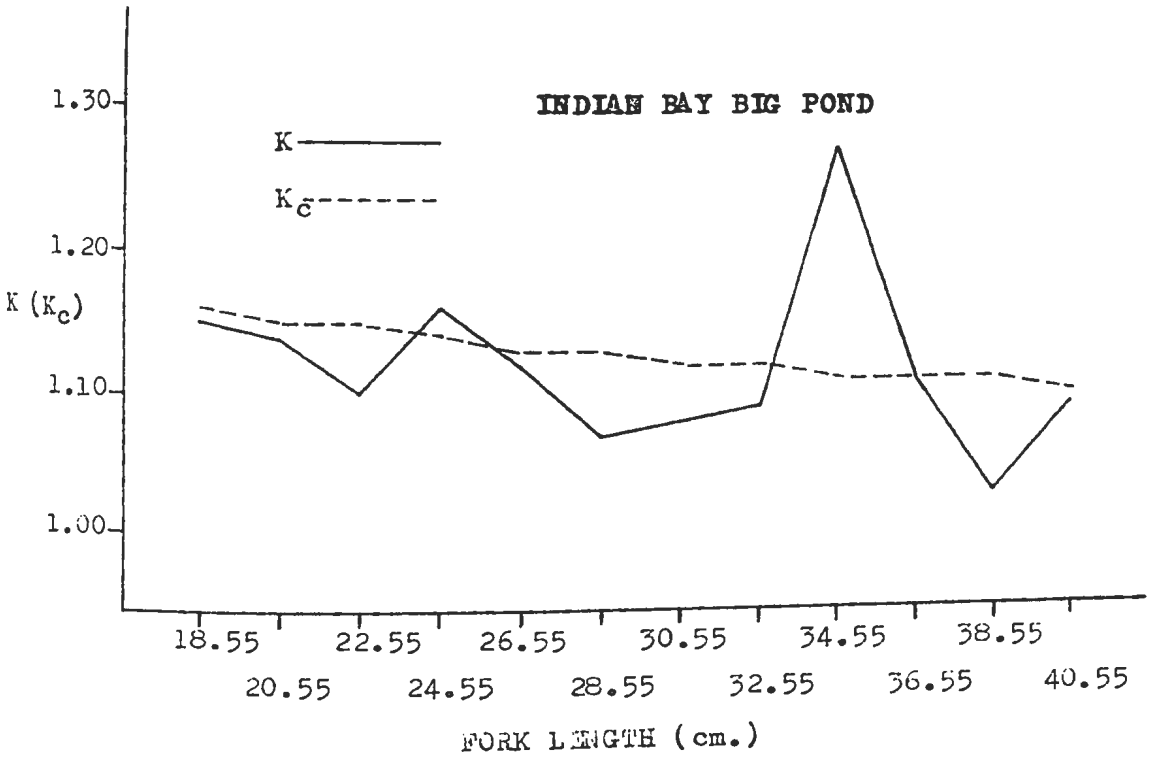
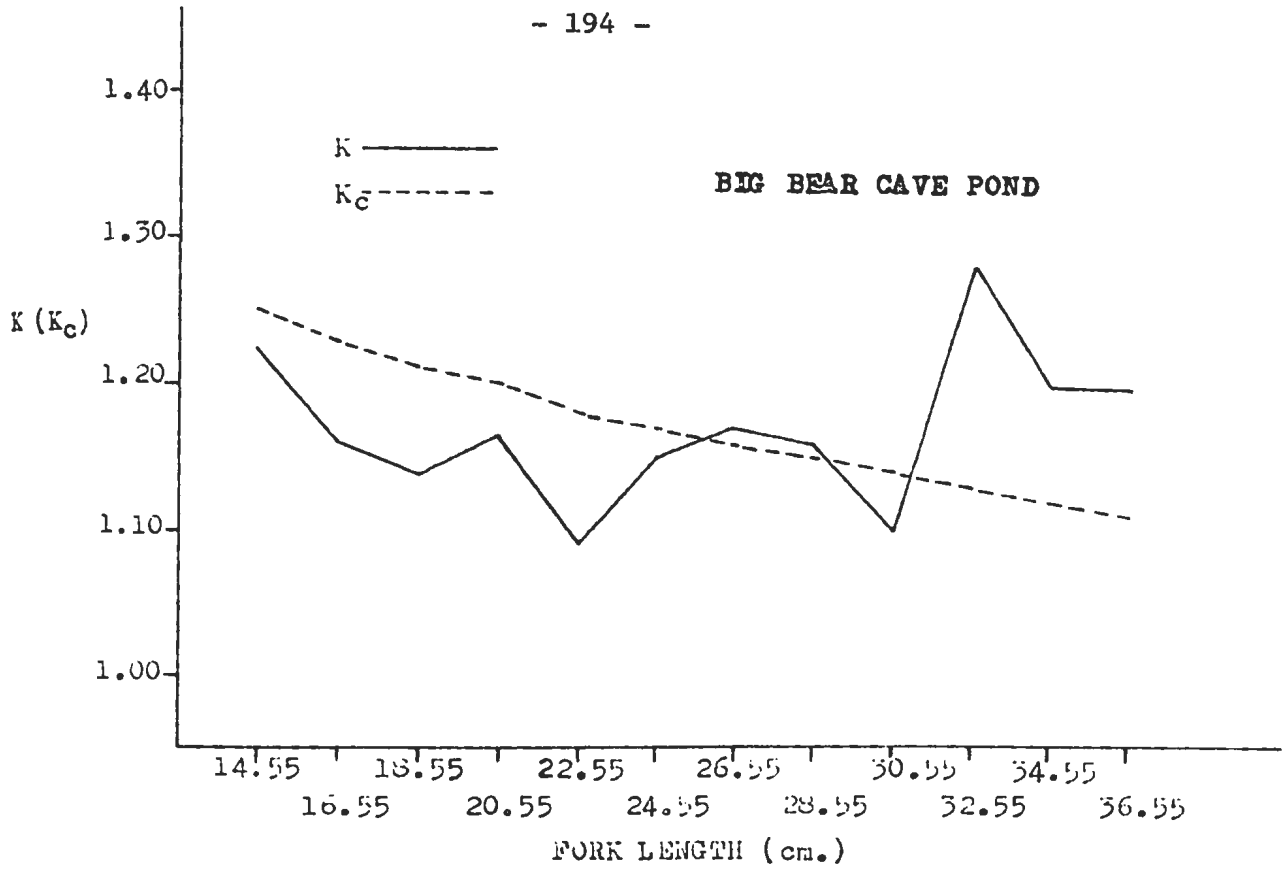


FIGURE VI: 16d. The variation of the condition factors K(Kc) with length for Thomas' and Indian Bay Big Ponds speckled trout.



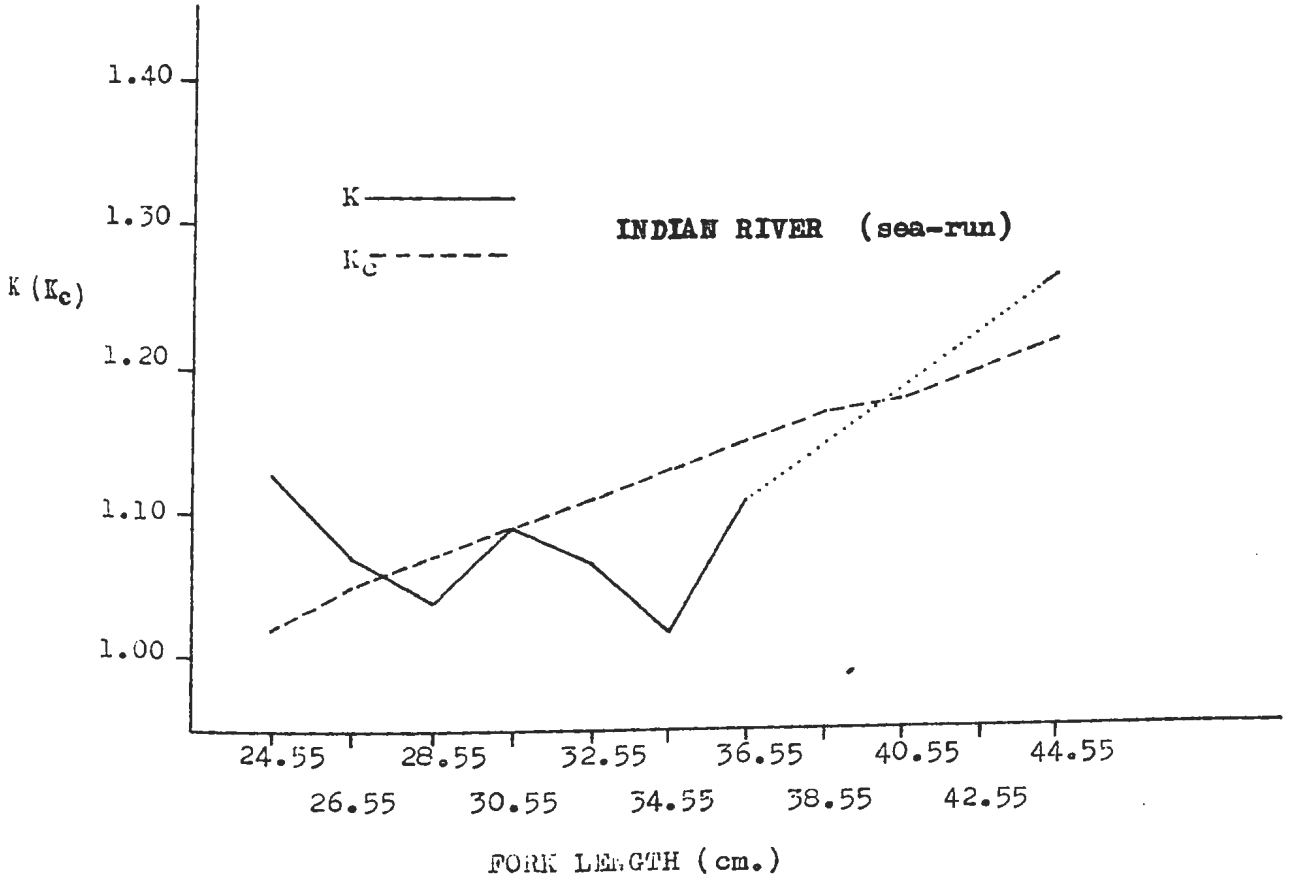


FIGURE VI: 16e. The variation of the condition factors K(Kc) with length for Big Bear Cave Pond resident and Indian River sea-run speckled trout.

factor. This means that except in rare cases where n = 3, the condition factors of fish of different lengths cannot be directly attributed to factors other than length. Therefore, any environmental factors effecting the value of n may in turn affect the value of the condition factor. Cooper and Benson (1951) therefore state that, "Because the coefficient of condition is based on the cube law, values of n in the more general formula indicate the direction and degree of change of the coefficient of condition of a species with an increase in size."

A possible explanation lies in the fact that Allen (1940) suggests that if condition is low at the beginning of the growing season, weight increases more rapidly than length, and since larger trout increase relatively more in weight than length normally, an increase in condition with increased length would be expected. On the other hand, a high condition coefficient at this period results in length increasing more rapidly than weight, thus larger trout which normally grow relatively faster in weight than length will have a lower condition factor than smaller trout, and thus condition would decrease with increased length. This aspect of growth and condition was also corroborated under laboratory conditions by Brown (1946).

Rounsefell and Everhart (1953) suggest the normal situation is for older fish to increase proportionately more in weight than length, and this condition increases with age. Therefore, when condition decreases with age or length, it is due to some deficiency or a limitation of some environmental factor. The most obvious factor would be the quality and quantity of food, and the efficiency of utilization of this food above and beyond maintenance requirements.

3. Variation of Condition with Sex

Menzies (1924) studying adult Atlantic salmon found that males were invariably thinner than females of the same length, and Hoar (1939) suggested male salmon parr were in better condition than females.

Hile (1936) however, points out that there is no consistent difference in the coefficient of condition of male and female ciscoes.

Table VI: 5 compares the condition factors between the sexes and gives the probabilities for significant differences. In both Berry Hill Pond and Angle Pond the males have significantly higher condition values ($p = 0.022$ and 0.0034 respectively), but only Angle Pond is significant at a probability of 0.01.

However, the female trout of Thomas' Pond are significantly heavier per given length than the males ($p = 0.00023$).

The fact that there is no consistent difference indicates that no clear cut sexual difference exists for the species as a whole.

When we consider that the value of the condition factor is correlated with the growth rate (Went and Frost, 1942; Allen, 1940; and Brown, 1946), it is not surprising to find the higher condition coefficients for males of Angle Pond and Berry Hill Pond. Recall that males exhibited faster growth in weight over all ages for Angle Pond, and that males of Berry Hill Pond grew faster in weight in later years, and also the males of Berry Hill Pond are heavier gutted than females over all lengths. Le Cren (1951) states that since males mature earlier in life than females and since the developing gonads constitute a large percentage of the whole weight, its contribution to the condition factor is significant.

If the foregoing suggestion for greater condition values for males is

TABLE VI: 5. A Comparison of condition factor values between sexes for speckled trout from various localities in Newfoundland.

LOCALITY	DATE	SEX	K Value	S.D.	S.E.	n.	p.
Stephen's Pond	Summer 1965	male	1.2221	0.0860	0.0134	41	0.18
		female	1.2464	0.0958	0.0121	63	
Thomas' Pond	June 1965	male	1.2281	0.1150	0.0167	47	0.0034**
		female	1.2907	0.1022	0.0134	58	
Angle Pond	June 1965	male	1.2759	0.0999	0.0144	48	0.00023**
		female	1.2075	0.0777	0.0099	62	
Big Bear Cave Pond	August 1965	male	1.1581	0.0844	0.0115	54	0.49
		female	1.1697	0.1016	0.0123	68	
Indian Bay Big Pond	June 1966	male	1.1234	0.0733	0.0096	58	0.79
		female	1.1194	0.0761	0.0117	42	
Berry Hill Pond	August 1966	male	1.1835	0.0738	0.0100	53	0.022*
		female	1.1438	0.0790	0.0142	31	
Indian River (stream-resident)	August 1966	male	1.1220	0.0938	0.0122	59	0.85
		female	1.1066	0.0798	0.0133	36	
Indian River (sea-run)	August 1966	male	1.0729	0.0500	0.0166	9	0.97
		female	1.0879	0.1045	0.0315	11	

* significant at $\alpha = .05$

** significant at $\alpha = .01$

valid, why should Thomas' Pond show higher values for females? It has already been shown that males are heavier than females in Thomas' Pond only at the older ages and upper lengths. The sex ratio however, is 58:47 in favour of females and may suggest differential angling mortality of faster growing and earlier maturing males, thus leaving the slower growing and therefore lower conditioned males.

4. Environmental Variations

(a) Short Term Seasonal Changes.

Superimposed on the progressive increase or decrease in condition which occurs with aging of the trout there are definite seasonal variations within the different year classes.

Generally, the annual cycle of condition is such that it is in phase with the annual gonadal cycle, and inversely related to the annual cycle of intestinal fat deposits. If however, condition factors based on weight-minus-gonad weight are used, this new condition factor is found to vary annually with the annual cycle of intestinal fat deposits and inversely with the gonadal cycle (Le Cren, 1951). Therefore the massive increase in gonad size is more than enough to offset the loss of weight due to decrease in storage fat deposits, and thus the cycle of condition is in phase with the gonadal cycle. When however, condition is based on weight-minus-gonad weight, it is readily seen that in fact condition per se is decreasing with the onset of sexual maturity as the growth slows and metabolism is directed towards developing gonads.

Figure VI: 17. shows the seasonal change in the mean value of the condition factor of Stephen's Pond trout throughout the summer of 1965. Data

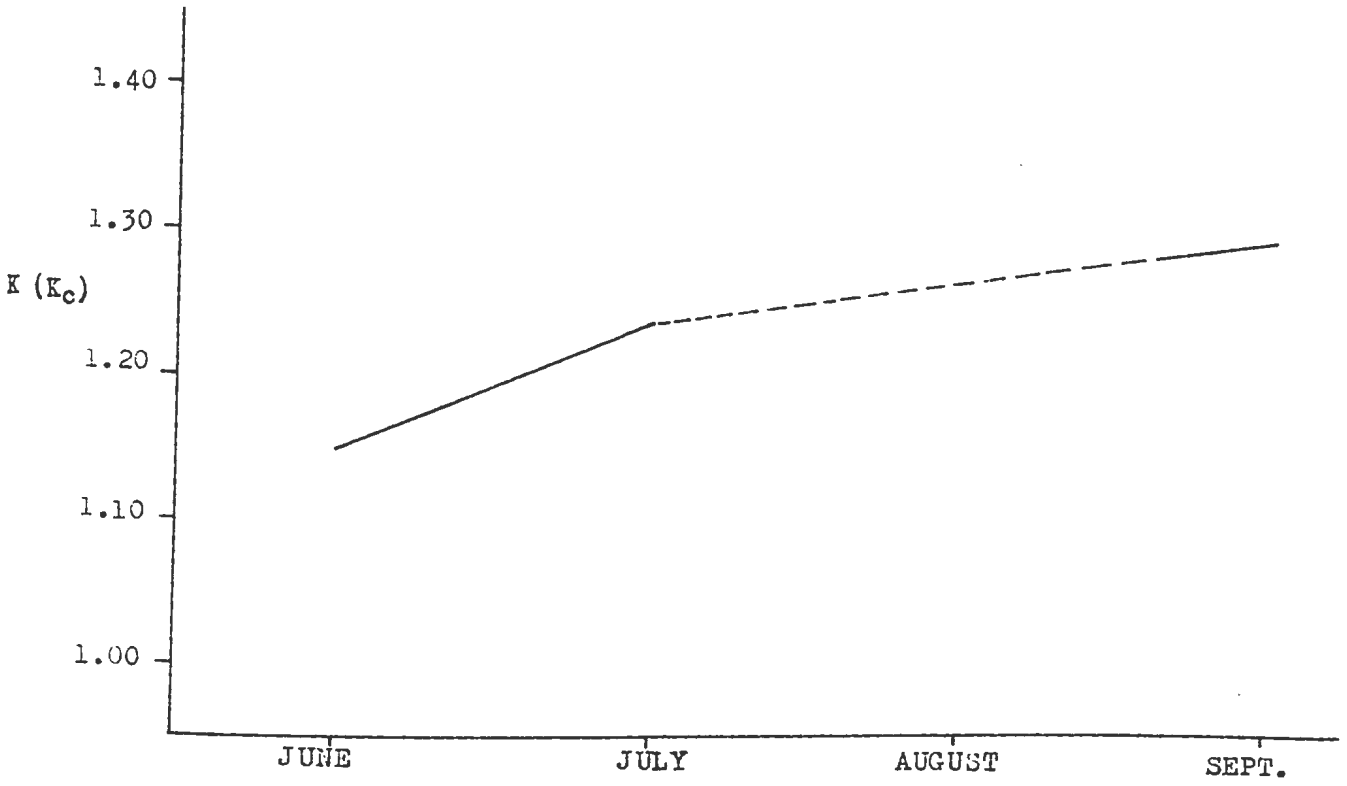


Fig. VI: 17.

Seasonal change in coefficient of condition (K) for Stephens' Pond speckled trout during the summer of 1965.
(Broken line indicates no data for August.)

were available for the months of June, July, and September, and indicate an increase from June to September; however, it was not possible to study the annual cycle.

Hazzard (1932) suggested speckled trout were "heaviest at the spawning season, losing weight thereafter, and not recovering condition until after several weeks of feeding in the spring."

Hecht (1916) and Hoover (1939) suggested condition in trout varies with the water temperature, and Embody (as reported by Hoover, 1939) suggests the condition coefficient of speckled trout gradually increases with increase in temperature until the temperature exceeds 70°F and then decreases.

Rupp (1955) states that for trout in Maine streams condition improves rapidly during the early season reaching a peak in June, and then declines during the hot part of the summer. Cooper and Benson (1951) report the same seasonal trend in Michigan.

McFadden (1961) shows a peak in condition in August for Wisconsin and a sharp decline during October and November coincident with the spawning season.

Shetter (as reported by Cooper et al., 1951) however, suggests that in a Michigan stream the peak was reached in May, then declined during July and August and increased again in September and October before declining again following spawning. Scherer (M.Sc. Thesis, 1963) reports much the same situation for two Pennsylvania streams.

It is obvious that seasonal studies of condition of speckled trout do not show uniform results. Although some variation has been noted, the general pattern is high condition in summer and low condition in winter. This pattern has usually been interpreted as a response to difference in temperature.

The influence of temperature however, may be indirect. Cooper (1953) suggests an apparent correlation between high condition factor and growth, and shows that growth in turn is correlated with seasonal water temperatures. McFadden (1961) also suggested the relationship for Wisconsin trout.

This was shown under controlled laboratory conditions by Brown (1946) for brown trout. She states, "Growth in length, which involves regional differentiation, occurs at a rate directly proportional to the condition factor and thus to the amount of food reserve."

(b) Long Term Environmental Influences.

As was previously mentioned condition may also be used to indicate the suitability of an environment and to measure the effects of environmental improvement. Condition may also be used to compare fish from one area with a general mean of the whole region.

Table VI: 6. gives the mean condition coefficients for all localities studied, with the corresponding surface acreage of the locality. The data are presented in Figure VI: 18 in a manner prescribed by Hubbs and Hubbs (1953).

It is readily noticeable that the overall mean condition coefficient bears a direct relationship with the habitat size. However, a positive correlation exists up to a point (approximately 1000 surface acres) and then the relationship becomes inverse with falling values of K with increased acreage.

The reasons for such changes were discussed earlier with respect to changes in length-weight relationships which are closely related to changes in condition.

The dominant factors are undoubtedly food, space, and temperature. Benson, 1954; Allen, 1940; and Neil, 1938 demonstrated a direct correlation

TABLE VI: 6. A Comparison of Condition Factor Values for localities sampled in Newfoundland.

LOCALITY	DATE	AREA (acres)	K Value	S.D.	S.E.	n.
Indian River (Sea-run)	August 1966	---	1.0811	0.0641	0.0143	20
Indian River (stream-resident)	August 1966	---	1.1161	0.0884	0.0090	95
Berry Hill Pond	August 1966	25.0	1.1688	0.0771	0.0084	84
Stephen's Pond	Summer 1965	35.0	1.2366	0.0921	0.0090	104
Angle Pond	June 1965	89.6	1.2373	0.0925	0.0088	110
Thomas' Pond	June 1965	256.0	1.2626	0.1110	0.0108	105
Big Bear Cave Pond	August 1965	1491.0	1.1646	0.1026	0.0093	122
Indian Bay Big Pond	June 1966	2413.0	1.1217	0.0746	0.0075	100

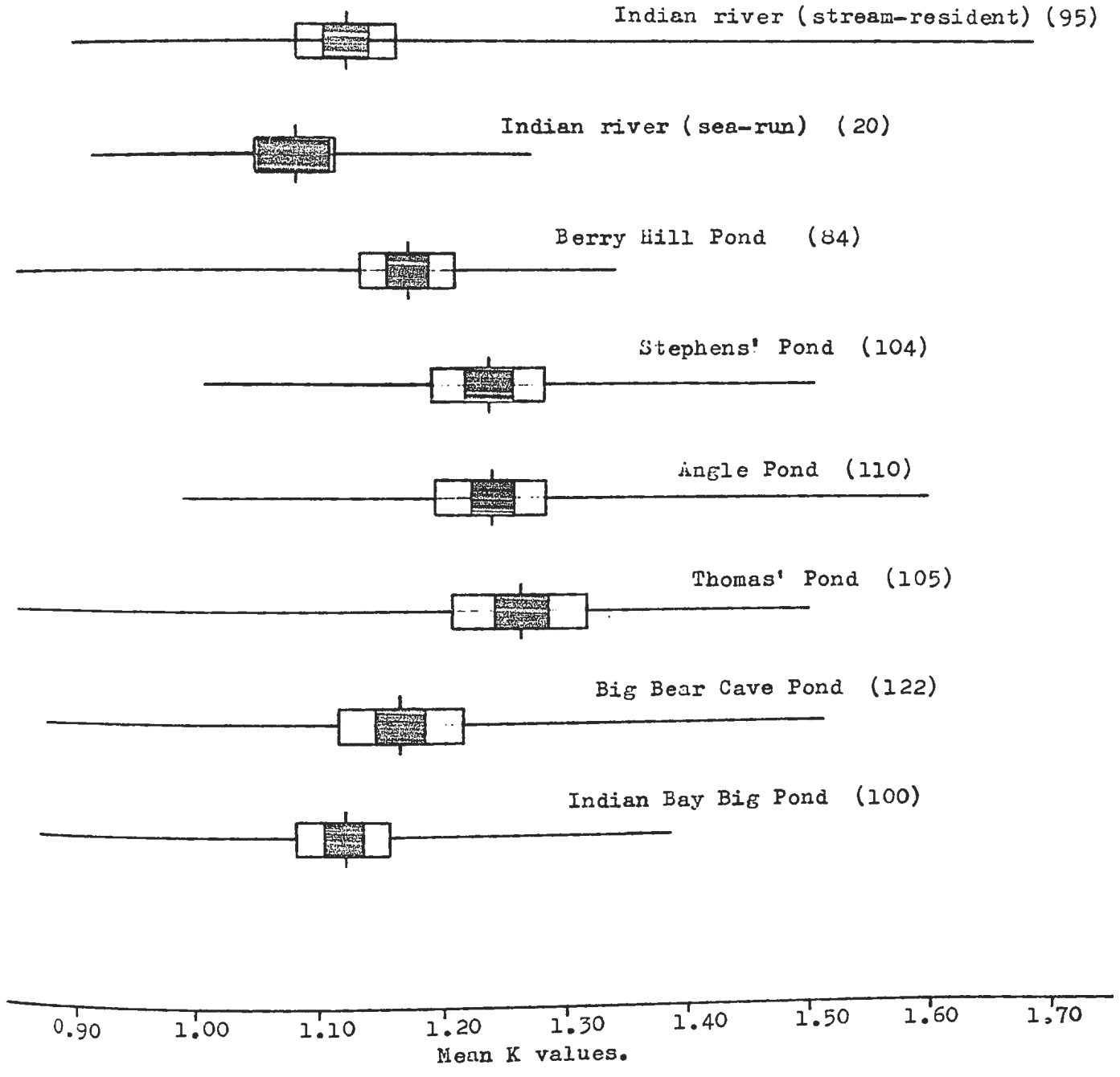


Fig. VI: 18.

Graphical comparison of mean coefficient of condition values of speckled trout from various localities in Newfoundland.

between volume of stomach contents and changes in condition for speckled trout, Atlantic salmon, and brown trout in a natural environment. This aspect will be given a more detailed study when the food of speckled trout is discussed, but it is probably sufficient at this stage to state that the smaller lentic environments are more productive and conducive to well-conditioned short trout, while larger areas are conducive to longer, poorer-conditioned trout because of lower productivity and the presence, though not abundance, of larger food organisms, and increased space.

Muttkowski, 1925; Hoover, 1939; and Ellis and Gowing, 1957 have shown that trout in lotic environments are often dependent on late summer terrestrial food to supplement sparse aquatic food, and this explains the very low K value for Indian River stream trout.

The condition value for sea trout as mentioned earlier is probably due to cessation of, or at least reduced, feeding in fresh water.

PART VII: MERISTIC VARIATION

A. INTRODUCTION

Meristic characters in fish can be described simply as those parts that differ in number among fish of the same species. Included in this definition we have such parts as vertebrae, gill rakers, fin rays, scale rows, pyloric caeca, branchiostegal rays, and pharyngeal teeth.

Meristic characters act as an indicator of identity and natural affinity of a species and are therefore used to separate races of populations of a fish species. This separation of races is based mainly on the fact that hydrological conditions during and sometimes shortly following the incubation period of the egg cause variations to occur in the number of serially arranged parts of the piscine anatomy. The magnitude of this environmentally induced variability is, however, limited by the genetic composition of the species.

Rounsefell and Everhart (1953) list several general rules for the selection of meristic characters to be used:

(1) The choice is between using many characters, thus being limited by time and small samples, perhaps inadequate, and using at most four or five characters with corresponding larger samples. They suggest the seeming benefit of using many characters in the hope of finding one or more yielding a significant difference is usually offset by the sample inadequacy.

(2) They suggest characters that result in much error in their enumeration should be avoided.

(3) Do not use two or more characters that are dependent on one another.

(4) Select a character in which there is a certain amount of variation. However, a character with an extremely wide range of variation would necessitate a large sample to locate the mean accurately.

In this study, only four meristic characters were used; these included vertebrae, gill rakers, dorsal and anal fin rays. In the use of each character some inherent problem or difficulty is encountered and this will be discussed more fully when the particular character is considered.

The ultimate aim of all meristic investigations is to be able to compare average counts of samples of fish from the same or different locality. In order to make the comparison valid and as accurate as possible, certain variations in meristic characters must be checked to make sure the results are not in some way biased by the particular features of the sample. In general, meristic characters may vary with fish length, sex, year class, and age.

In this study it was felt that some, if not all, of these variations should be investigated in order to determine to what extent they bias the mean count for an area.

B. VERTEBRAL COUNTS

Four general areas of the Province were studied for variation in vertebral count. These areas were the Avalon Peninsula (Stephen's Pond, Thomas' Pond, and Angle Pond); the Burin Peninsula (Berry Hill Pond); Bonavista North (Big Bear Cave Pond and Indian Bay Big Pond); and Notre Dame Bay (Indian River).

Following the routine measurements and observations, the fish were filleted and as much of the flesh as possible was removed. The filleted fish

were then boiled in a shallow pan for about one half hour. They were then placed on a piece of wire gauze and a jet of hot water directed to remove the residual flesh. The vertebral column was then stained with alizarin red and allowed to dry. This procedure was used for all samples except those from Indian River where the radiographic technique was used.

Following drying, a careful count of each column was made. The total count method of Hubbs and Lagler (1964) was used with the hyplural plate complex counted as three vertebrae. (Figure VII: 1). Columns containing abnormal or complex vertebrae (Garside, 1966) were not included in the counts and were discarded. It was found that such columns constitute a small percentage of the total number of columns. All counts were made by the author, with a second and third random count made at separated time intervals.

Counts from the radiographs were made using an illuminated glass top drawing table. A hand lens was used to facilitate counting.

1. VARIATION WITH SEX

Differences in mean counts between areas might only reflect differences in sex ratios if sexual dimorphism is exhibited in vertebral number. For this reason it was decided to determine if such sexual dimorphism existed.

Sexual dimorphism in meristic characters, in general, is rare among fishes.

Templeman (1948) found that capelin (Mallotus villosus) in the Newfoundland area showed this sexual dimorphism, with females having a higher number. Hart (1937) and Hart and McHugh (1944) found that for Pacific capelin the males had the highest number. Hubbs (1925) found evidence of sexual dimorphism in the Pacific anchovy (Engraulis mordax mordax). Punnett (1904)

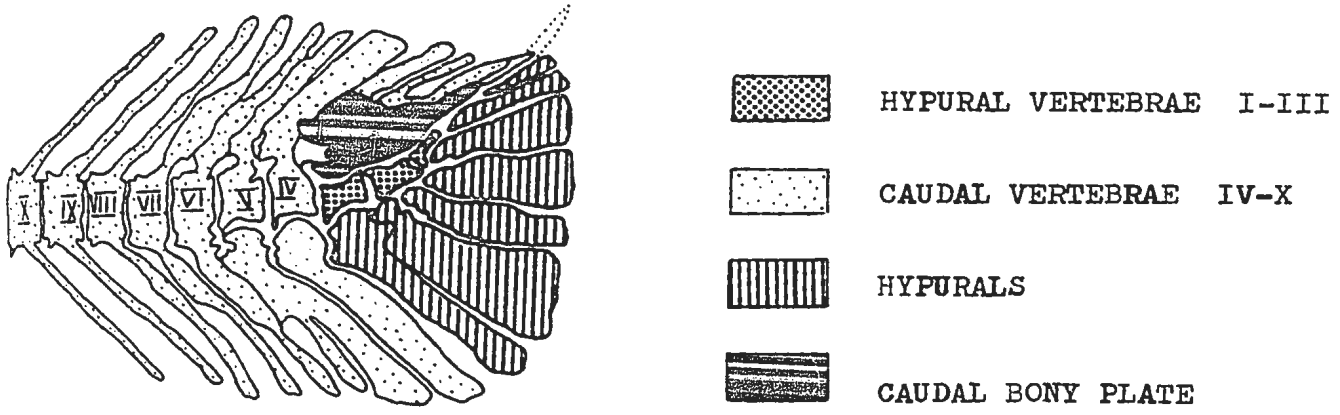


FIGURE VII: 1. Hyplural plate complex of Salvelinus fontinalis, counted as first three vertebrae.

working on an elasmobranch (Spinax niger) found females to have significantly higher counts than males.

On the other hand, Schaefer (1936) found no evidence of difference for the surf smelt, Hypomesus pretiosus; Tester (1937) states there is no sexual dimorphism for the Pacific herring, Clupea pallasii; Hart (1937) reports no sexual dimorphism for the pilchard, Sardinops caerula; and Pitt (1963) found no evidence of sexual dimorphism for the American plaice, Hippoglossoides platessoides.

Table VII: 1 compares the vertebral counts of male and female speckled trout. Both Big Bear Cave Pond and Angle Pond male trout have significantly higher vertebral numbers than females ($P = 0.047$ and 0.0046 respectively). In all other localities there are no significant differences. Combining all localities shows no general sexual dimorphism for Newfoundland speckled trout ($P = 0.75$).

TABLE VII: 1. Comparison of vertebral counts between sexes for speckled trout from various localities in Newfoundland.

LOCALITY	SEX	MEAN VERTEBRAL NO.	S.D.	S.E.	P value
Berry Hill Pond	male	57.9811 (53)	.7204	.0989	0.25
	female	58.1666 (30)	.6997	.1277	
Thomas' Pond	male	58.7173 (46)	.7199	.1061	0.26
	female	58.8750 (56)	.6048	.0808	
Stephen's Pond	male	58.9230 (39)	.8073	.1292	0.36
	female	58.7777 (63)	.7502	.0945	
Big Bear Cave Pond	male	58.3000 (50)	.7353	.1039	0.047*
	female	58.0000 (65)	.8825	.1094	
Indian Bay Big Pond	male	58.1206 (58)	.6996	.0918	0.23
	female	58.2857 (42)	.6698	.1033	
Angle Pond	male	58.9787 (47)	.6076	.0886	0.0046*
	female	58.6290 (62)	.6831	.0867	
GRAND TOTALS	male	58.4641 (293)	.8075	.0471	0.75
	female	58.4842 (318)	.7850	.0440	

* significant at a probability of 0.05.
** significant at a probability of 0.01.

The reason for the isolated cases of apparent sexual dimorphism for Big Bear Cave Pond and Angle Pond trout may be differential growth rate as suggested by Thompson (1917). Recall that male trout in Big Bear Cave Pond have a consistently faster growth rate, while male trout in Angle Pond are growing faster than females, at least in the early years of life. Because differential, angling mortality would be selective for males; in actual fact the growth rate of males may be faster over all ages. Gray (1929), working on the sea-trout (Salmo fario) found a negative correlation between temperature and the size of the embryo; i.e., the lowest temperature produced the largest embryos. It has also been shown that the number of vertebrae is negatively correlated with temperature and rate of development (Gabriel, 1944; Barlow, 1961; and Garside, 1966). Therefore, as Tester (1937) suggests, there is a slight tendency for larger fish to have a higher vertebral count than smaller fish.

The validity of this reason in explaining the difference in count between sexes depends on the assumption that low temperature during incubation is selective in producing larger male embryos and thus, as Brown (1946) suggests, this size hierarchy at hatching is maintained throughout life.

Any slight difference in vertebral number would then be accentuated by the sex ratios which favour the slower growing females; 65 : 50 and 62 : 47 for Big Bear Cave Pond and Angle Pond respectively.

It is felt though that little appreciable error is introduced in combining the counts for the two sexes.

2. OTHER SOURCES OF VARIATION

(a) Variation with Length

As was already discussed, there is a slight tendency for the larger fish to have a slightly higher vertebral count than the smaller fish, and this is caused by differential developmental rates (Gabriel, 1944; Barlow, 1961; and Garside, 1966). Mottley (1936) found the number of vertebrae in the rainbow trout, Salmo gairdneri, was correlated with length. No attempt was made in this study to determine if such a correlation exists for speckled trout as extremely large samples are required for any degree of certainty. But this variation must be kept in mind when comparing two samples which exhibit a size disparity.

(b) Variation with Year Class

The possibility also exists that mean counts of year-classes from the same locality may differ so widely that the difference in mean counts of the samples, both between and within localities, may merely reflect differences or changes in age composition (Tester, 1937; and Vilhjalmsson, 1966).

These differences generally reflect environmental changes, especially temperature under which the egg is incubated.

Again, no attempt was made to examine this source of variation because of the small numbers of fish in each year class from each locality.

(c) Variation with Age

The mean vertebral count of a year class of fish may either increase or decrease as the year class becomes older. This is due to the new recruits added or older fish dropping out. These additions or losses may be characterized by high or low vertebral numbers. This problem is particularly important where intermingling of stocks occurs, for example, Day (1957) suggests counts tend to increase as the year class of herring becomes older.

For isolated populations of trout, this variation would be lessened to a great extent, and any variation would probably be due to differential mortality with respect to vertebral counts.

3. VARIATION WITH LOCALITY

What little work there has been done on the Salmonidae in freshwater has been to distinguish between species or sub-species. Belding (1936) used vertebral counts to attempt to show population differences for Newfoundland Atlantic salmon parr. Mottley (1937) reviewed the number of vertebrae in trout of the genus Salmo. Wilder (1947) made a comparative study of the Atlantic salmon and the land-locked salmon of Nova Scotia, and in 1952 carried out a similar comparative study of anadromous and freshwater populations of speckled trout in Nova Scotia. Neave (1943) used vertebral counts to attempt a comparison of anadromous and non-anadromous rainbow trout. Andrews and Lear (1956) used vertebral counts to separate populations of Labrador arctic char.

The frequency distributions and means of the vertebral counts from the various localities in Newfoundland are given in Table VII: 2. with the respective latitudes of the localities. It will be noted that the lowest count is for the area of lowest latitude (Berry Hill Pond, Burin Peninsula), while the highest count (Indian River, Notre Dame Bay) is for the highest latitude, which generally follows Jordan's (1893) Rule. However, the Indian Bay area which is intermediate in latitude between the Avalon Peninsula and Notre Dame Bay has a vertebral count which is less than that for the Avalon Peninsula.

Because temperature and developmental rate are so closely associated with vertebral numbers it was felt that some knowledge of the temperature

TABLE VII: 2. Variation in the vertebral count of speckled trout from various localities in Newfoundland and for the Nova Scotian hatchery trout.

LOCALITY AND LATITUDE	Number of Vertebrae										
	56	57	58	59	60	61	62	Mean	No.	S.D.	S.E.
Berry Hill Pond 47° 05'	2	13	47	21	--	--	--	58.0481	83	0.7132	0.0782
Thomas' Pond 47° 21'	--	4	22	66	10	--	--	58.8039	102	0.6606	0.0654
Stephen's Pond 47° 21'	--	1	36	45	19	1	--	58.8333	102	0.7709	0.0763
Angle Pond 47° 24'	--	1	36	58	14	--	--	58.7798	109	0.6684	0.0640
Big Bear Cave Pond 49° 07'	--	26	52	33	4	--	--	58.1304	115	0.7995	0.0745
Indian Bay Big Pond 49° 04'	--	14	55	29	2	--	--	58.1900	100	0.6947	0.0694
Indian River (Stream) 49° 27'	--	--	14	38	28	9	2	59.4175	91	0.9455	0.0991
Indian River (Sea-run) 49° 27'	--	--	2	8	9	1	--	59.4500	20	0.7574	0.1693
GRAND TOTALS	2	59	264	298	86	11	2	58.6204	722	0.8803	0.0327
Nova Scotia (Hatchery trout)	7	28	27	8	--	--	--	57.5142	70	0.8296	0.0991

during incubation would be useful in explaining the variation in vertebral counts between localities.

Because speckled trout generally spawn from October to November in Newfoundland, and the young emerge around April the following year, it was decided to use the mean temperature during the five month period, December to April.

Hare (1952) gives the mean monthly air temperatures at several climatological stations in Newfoundland; these means are based on temperatures recorded at the station throughout its history of operation. The mean air temperatures for the months December to April were averaged, and the grand mean represented the average air incubation temperature. It was assumed that the air temperature bears a direct relationship with water temperature.

The data from St. John's and Cape Race were combined and used as representative of the Avalon Peninsula. The Burin Peninsula was represented by Grand Bank data, while the Indian Bay area temperatures were based on those from Gander. The closest station to Notre Dame Bay was Deer Lake and its data were taken as being fairly representative of the area.

Table VII: 3. gives the mean vertebral counts for the various localities with their respective latitudes and mean air incubation temperatures. It will be seen that temperature is directly correlated with latitude and negatively correlated with vertebral counts, except for the Indian Bay area.

Vladykov (1934) reports that Gunther (1862) was the first to point to the relationship between vertebral numbers in fish and latitude, i.e. temperature. Jordan (1893) put this observation into a rule stating that vertebral numbers increase with increasing latitude, from coastal waters to open seas, and from brackish to fresh water conditions. Earlier explanations (Jordan, 1893; and

TABLE VII: 3. The relationship between the number of vertebrae and the latitude, with the approximate mean air temperature during the months of egg incubation. (December to April).

LOCALITY	LATITUDE	Mean Incubation Temperature (Air)	Vertebral Number
Berry Hill Pond	47° 05'	28.10°F.	58.0481
Thomas' Pond	47° 21'	25.70°F.	58.8039
Stephen's Pond	47° 21'	25.70°F.	58.8333
Angle Pond	47° 24'	25.70°F.	58.7798
Indian Bay Big Pond	49° 04'	23.90°F.	58.1900
Big Bear Cave Pond	49° 07'	23.90°F.	58.1304
Indian River (Stream)	49° 27'	20.00°F.	59.4175
Indian River (Sea-run)	49° 27'	20.00°F.	59.4500

Huntsman, 1919) suggested that genetic differences were responsible for differences in vertebral numbers.

Schmidt (1919), however, showed for the brown trout that while heredity does play a part, the external environment (temperature in particular) is also effective in determining the final number of vertebrae a particular species has. Schmidt was followed by such workers as Hubbs (1922), Mottley (1934, 1937), Gabriel (1944), Täning (1944, 1952), Lindsey (1954), Seymour (1959), and Garside (1966), who also show the influence of temperature on vertebral numbers.

Täning (1944, 1952) carried out classical experiments to determine the precise time at which the vertebral number is established in the brown trout. Täning found that the plastic period was just before the "eyed-egg" stage. He found that if the temperature is changed before 40 day degrees (D^{o}) after fertilization, the vertebral number will change to a value that the fish would have had if the entire development had occurred at the new temperature. In the period 40 - 100 D^{o} sluggishness towards change in vertebral number is apparent, and from about 100 - 143 D^{o}, slight changes in temperature produce no change in vertebral number. If, however, from 145 - 165 D^{o} the embryo is subjected to sudden temperature changes, the meristic count is very markedly changed. Täning found that during this "supersensitive" period a relatively moderate change in temperature can produce an average change of about 1½ vertebrae. Subjecting the embryos to extreme changes (ca. 10-14°C) however, can produce very marked changes of a 3-4 vertebrae difference between offspring of the same parents. Both Gabriel (1944) and Dannevig (1950) agree that the plastic period is before the "eyed-egg" stage.

Lindsey (1954) and Molander and Molander-Swedmark (1957), however, found that in the paradise fish, Macropodus opercularis (L.) and the plaice, Pleuronectes platessa, respectively, the plastic period occurs after hatching. It is therefore obvious that when we attempt to correlate vertebral number with water temperature we are not sure at what time the temperature acts. For this reason the mean air incubation temperatures of Table VII: 3. are taken over the whole period of incubation.

Therefore, if temperature can affect the number of vertebrae, the next question is how exactly does temperature act on the developing larvae to produce low vertebral counts at high temperatures and vice versa?

Gray (1929) using the sea trout, Salmo fario, found that eggs incubated at the lower temperatures produced larger embryos. He suggests that at high temperatures a larger proportion of yolk is required for maintenance of embryonic tissue and consequently less is available for conversion into new tissue. This could possibly explain the negative correlation of temperature and vertebral numbers.

Blaxter (1957) working with herring myotome counts also gives the same indication; fewer myotomes formed at higher temperatures.

Hubbs (1926) and Gabriel (1944) also consider developmental rates to determine meristic characters through the control of growth and differentiation. This is based on the assumption that low temperatures retard growth relatively more than differentiation. Therefore, at low temperatures growth will be retarded but the rate of formation of vertebrae will be relatively less diminished. Hence, vertebrae will form over a relatively longer period of time and so more of them will be laid down. On the other hand, high temperatures and rapid growth does not permit the differentiation of as many vertebral elements.

Garside (1966) exposed the eggs of the speckled and rainbow trout to various constant levels of temperature and dissolved oxygen to determine if indeed vertebral number is regulated by the developmental rate as proposed by Hubbs (1926), Gabriel (1944), and Barlow (1961). He found that the mean vertebral number in both species was inversely related to the developmental rate expressed as the reciprocal of the number of days in the numerical determination of vertebrae in each species.

If we therefore assume that the mean incubation temperatures given in Table VII: 3. are reasonably accurate, and that developmental rates are correlated with temperature, we can assume that for the most part variation in vertebral count is due to variation in developmental rates. We are, however, still left with the Indian Bay counts which do not fit into the general scheme.

The two ponds in the area are approximately 10 miles apart and were sampled in two different years. Since the two counts were not significantly different ($P = 0.55$), this would seem to indicate no year class variation. The closeness of the two counts would also indicate that the environmental conditions are quite similar, and it would appear doubtful that the fish were inhabiting an isolated thermal regime different from that of the general area from which the mean incubation temperature was calculated (Gander) which is about 20 miles away.

The variation of the Indian Bay counts from the expected trend may, of course, not be due to temperature influence. Many other environmental factors have been suggested as affecting meristic variation, and often these factors work in combination.

Garside (1966) suggests a combination of high temperature and high oxygen concentration causes a low vertebral count. Täning (1952) found that higher vertebral counts result from low oxygen tension.

Dannevig (1932) points to the possibility of reduced vertebral number in cod as a result of higher light intensity. McHugh (1954) and Lindsey (1958) found that vertebral counts in the grunion, Leuresthes tenuis (Ayres), and kokanee, Oncorhynchus nerka, respectively, were negatively correlated with light intensity. It is suggested that like temperature, increased light speeds up the hatching time and tends to lower the vertebral number. It has also been suggested that light intensity could complement the latitude effect of temperature.

Vladykov (1934) suggests the "space factor" as a possible influence on meristic variation. He suggests fish from larger bodies of water generally have more meristic parts than those from smaller areas.

It is therefore obvious that any one of these factors or any combination of factors, is able to influence meristic counts. It is therefore impossible to suggest a reason for the apparent deviation from the normal latitudinal trend seen in the Indian Bay trout unless complete environmental data were available.

The method of graphic presentation of means (Hubbs and Hubbs, 1953) was used as the primary test for determining significant differences among the various means (Figure VII; 2). For more accurate decisions the "t test" was used.

It was found that the three Avalon Peninsula samples were not significantly different. When tested in all three combinations the probabilities were:

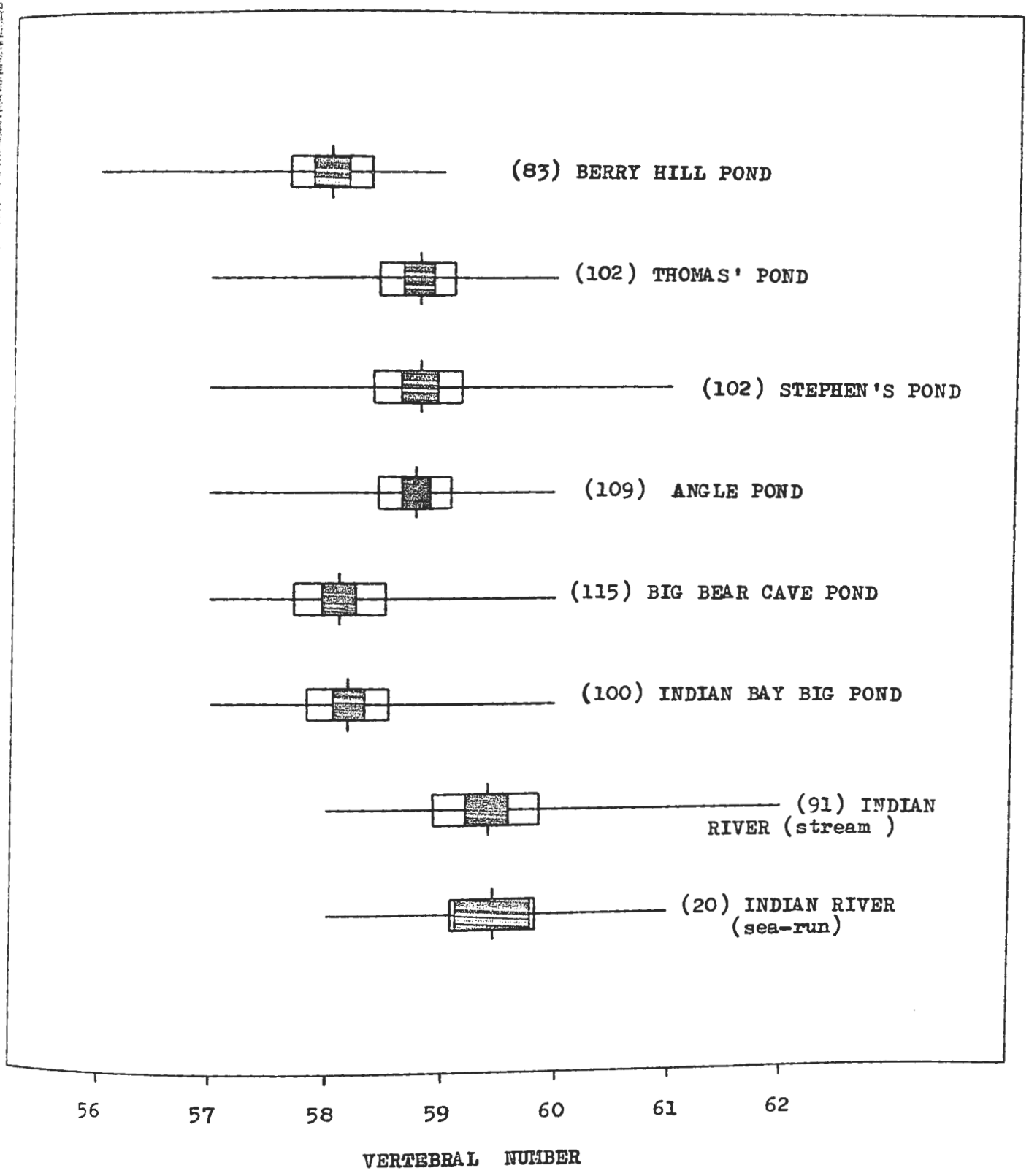


FIGURE VII: 2. Graphical comparison of vertebral counts for speckled trout from various Newfoundland localities.

(1) p(S,T) = 0.77; (2) p(S,A) = 0.59; and (3) p(T,A) = 0.54. (S,T, and A are abbreviations for the names of the ponds). The three samples were then combined.

The two Indian Bay samples were not significantly different (p = 0.55) and so these two were combined.

The two Indian River samples were also combined because there was no significant difference (p = 0.87).

Then the four areas, Avalon Peninsula, Burin Peninsula, Indian Bay and Indian River were t tested in all combinations. The results indicate that the Avalon Peninsula, Indian Bay and Indian River were all significantly different from each other at a probability of 0.01. The Burin Peninsula sample, however, did not differ significantly from the Indian Bay sample (p = 0.23). However, a larger sample from the Burin Peninsula may have changed the situation. It would therefore appear that through geographic separation the speckled trout in the four general areas studied are distinct with respect to vertebral numbers.

Two reports of meristic work on Newfoundland salmonids are found in the literature. Belding (1936) found significant differences in vertebral counts between various areas for Atlantic salmon parr, which he attributed to "different environmental conditions". Andrews and Lear (1956) found a correlation between vertebral number and latitude for Labrador arctic char.

4. Variation in Vertebral Numbers between Newfoundland and other North American Localities

Bigelow et al. (1963) give the vertebral range for speckled trout as 58 - 62 for the Western North Atlantic, with an average of 59.5. Vladykov

(1954) also gives a range of 58 - 62 for Quebec with a mean of 59.5, and this is probably the data used by Bigelow et al. (1963).

In this study the range in vertebral numbers for Newfoundland was 56 - 62, with a mean of 58.6 vertebrae.

Norden (1961) gives a range of 55 - 59 for Michigan speckled trout, with a mean of 56.3 vertebrae.

Wilder (1952) gives a mean of 56.9 for Moser River speckled trout in Nova Scotia. In this study a sample of speckled trout from a Nova Scotia hatchery had a range of 56 - 59 and a mean of 57.5 vertebrae.

It is therefore obvious that there is some geographic variation in vertebral numbers for North American speckled trout.

Table VII: 4. gives some means for several North American localities. The Ontario mean was calculated from Garside's (1966) data on the number of vertebrae produced at 2.5°C because this was taken as being close to the natural incubation temperature of 1.7°C given by Embody (1934). The Nova Scotia mean was calculated from data given by Wilder (1952) for both sea and fresh water trout. In all cases total counts were used as given by Hubbs and Lagler (1964).

The number of vertebrae of the Nova Scotia hatchery trout differed from all Newfoundland counts ($p = 0.01$).

From Table VII: 4. it would appear that the vertebral numbers show a latitudinal variation with lowest counts from areas south of Newfoundland and the highest count for northern Quebec which is north of Newfoundland.

C. GILL RAKER COUNTS

Gill raker counts were made following Hubbs and Lagler (1964). The gill rakers were counted by dissecting out the first gill arch on the left

TABLE VII: 4. Variation in Vertebral Numbers for various North American localities.

LOCALITY	Mean Vertebral Number	No. of fish	Source
Michigan	56.30	(10)	Norden, 1961
Ontario	57.88	(132)	Garside, 1966
Nova Scotia	56.86	(49)	Wilder, 1952
	57.51	(70)	This thesis
Newfoundland	58.62	(722)	This thesis
Quebec	59.50	(13)	Vladykov, 1954

side and counting the rakers under a binocular microscope. Counts were made for the entire limb and for upper and lower limbs separately. All rudimentary rakers were included. All counts were made by the author with second and third random check counts made at widely spaced time intervals.

Bigelow et al. (1963) suggest the number of gill rakers in speckled trout averages 4 - 8 on the lower limb, 7 - 9 on the upper limb, and 11 - 17 for the total count. Jordan and Evermann (1896) simply state "gill rakers are about 6 + 11".

Slastenenko (1958) states that the total number of gill rakers ranges from 11 - 22 in Canadian waters.

The importance of stating from which side the count was made is readily seen in Table VII: 5. where counts for Indian Bay Big Pond (Newfoundland) and Nova Scotia hatchery trout are compared for left and right gill arches. It appears, as Vladykov (1954), suggests, that the number of gill rakers on the right side is somewhat higher than that on the left.

As with other meristic characters, there are a number of variables which must be checked to see if the results are in any way biased by the nature of the sample. Before a comparison of gill raker counts between localities was attempted, it was decided to test for variations of two types: (1) variation with age or length, and (2) sexual dimorphism.

1. Variation with Age or Length

Vladykov (1954) states that although gill raker counts are a favourite meristic tool for those who study the Coregonidae, it is apparently of little value for chars (Salvelinus) because the number tends to increase with age. This is in general agreement with Foerster and Pritchard (1934) and Wilder (1947) who found that the number increases with size in the Atlantic salmon, and also with Wilder (1952) who found the same relationship for speckled trout.

On the other hand, McPhail (1961) uses gill rakers as taxonomic characters for Salvelinus malma and Salvelinus alpinus and using correlation coefficients, found no such correlation and suggests Vladykov's criticism of gill rakers is invalid for these two species.

The relationship between the number of gill rakers and age (length) is shown in Tables VII: 6-8. The correlation coefficients are calculated after Hoel (1965).

TABLE VII: 5. Comparison of right and left arch gill raker counts for speckled trout.

LOCALITY	TOTAL NUMBER OF GILL RAKERS										
	15	16	17	18	19	20	21	Mean.	No.	S.D.	S.E.
Indian Bay Big Pond (lt)	1	10	30	31	24	3	1	17.8000	100	1.1010	0.1101
(Rt)	--	6	23	37	29	3	2	18.0600	100	1.1330	0.1133
Nova Scotia (Lt)	9	26	30	4	1	--	--	16.4571	70	0.8444	0.1009
(Hatchery) (Rt)	1	9	34	24	2	--	--	17.2428	70	0.7712	0.0922

	Number of upper limb gill rakers							
	6	7	8	9	Mean.	No.	S.D.	S.E.
Indian Bay Big Pond (Lt)	1	55	42	2	7.4500	100	0.5550	0.0555
(Rt)	4	44	43	9	7.5700	100	0.7107	0.0710
Nova Scotia (Hatchery) (Lt)	9	57	3	1	6.9428	70	0.4780	0.0571
(Rt)	--	42	27	1	7.4142	70	0.5264	0.0629

	Number of lower limb gill rakers									
	8	9	10	11	12	13	Mean.	No.	S.D.	S.E.
Indian Bay (Lt) Big Pond (Rt)	1	14	42	35	8	--	10.3500	100	0.8558	0.0855
	--	7	47	37	8	1	10.4900	100	0.7848	0.0784
Nova Scotia (Lt)	3	29	37	1	--	--	9.5142	70	0.6077	0.0726
(Hatchery) (Rt)	1	17	45	7	--	--	9.8285	70	0.6141	0.0734

TABLE VII: 6. Correlation of total gill raker counts with age for speckled trout from various localities in Newfoundland.

LOCALITY	AVERAGE TOTAL GILL RAKERS AGE (Years)							
	I^+	II^+	III^+	IV^+	V^+	VI^+	r.	p.
Berry Hill Pond	15.00 (2)	16.12 (45)	16.69 (32)	17.67 (6)	---	---	0.9930	0.0082**
Thomas' Pond	16.50 (2)	16.67 (47)	16.96 (56)	---	---	---	0.9787	0.022**
Stephen's Pond[1.]	15.00 (1)	16.25 (28)	16.55 (71)	17.33 (3)	16.00 (1)	---	0.9720	0.036**
Angle Pond[2.]	15.83 (6)	16.67 (42)	16.66 (57)	17.00 (4)	16.00 (1)	---	0.9060	0.13
Big Bear Cave Pond	15.00 (2)	16.48 (77)	17.29 (32)	17.88 (9)	18.00 (2)	---	0.9470	0.0096**
Indian Bay Big Pond	---	17.33 (6)	17.82 (61)	18.25 (24)	18.13 (8)	19.00 (1)	0.9412	0.013**
Indian River (Stream-resident)	---	16.33 (40)	16.72 (35)	16.40 (5)	---	---	0.170	0.86
Indian River (Sea-run)	---	---	17.00 (2)	17.43 (7)	16.90 (10)	18.00 (1)	0.951	0.067
GRAND TOTALS	15.67 (12)	16.46 (285)	16.96 (346)	17.74 (58)	17.37 (22)	18.50 (2)	0.9518	0.0007**

** sig. linear correlation
1. disregarding age V^+ count.
2. disregarding age V^+ count.

TABLE VII: 7. Correlation of upper limb gill raker counts with age for speckled trout from various localities in Newfoundland.

LOCALITY	AVERAGE UPPER LIMB GILL RAKERS Age (Years) I+	II+	III+	IV+	V+	VI+	r.	p.
Berry Hill Pond	6.00 (1)	6.36 (45)	6.69 (32)	7.67 (6)	--	--	0.9621	0.048**
Thomas' Pond	6.50 (2)	6.82 (47)	6.98 (56)	--	--	--	0.9938	0.008**
Stephen's Pond[1].	6.00 (1)	6.51 (28)	6.60 (71)	7.33 (3)	7.00 (1)	--	0.9650	0.036**
Angle Pond[2].	6.33 (6)	6.65 (42)	6.86 (57)	6.75 (4)	6.00 (1)	--	0.8340	0.23
Big Bear Cave Pond	6.00 (2)	6.58 (77)	6.83 (32)	7.66 (9)	7.00 (2)	--	0.8030	0.12
Indian Bay Big Pond	--	7.33 (6)	7.59 (61)	7.54 (24)	7.38 (8)	8.00 (1)	0.6777	0.24
Indian River (Stream-resident)	--	6.60 (40)	6.89 (35)	6.80 (5)	--	--	0.6818	0.829
Indian River (Sea-run)	--	--	7.00 (2)	7.00 (7)	7.10 (10)	8.00 (1)	0.8241	0.75
GRAND TOTALS	6.25 (12)	6.61 (285)	6.94 (346)	7.38 (58)	7.14 (22)	8.00 (2)	0.9436	0.002**

** Sig. linear correlation.

1. disregarding age V+ count.

2. disregarding age V+ count.

TABLE VII: 8. Correlation of lower limb gill raker counts with age for speckled trout from various localities in Newfoundland.

LOCALITY	AVERAGE LOWER LIMB GILL RAKERS Age (Years) I+	II+	III+	IV+	V+	VI+	r.	p.
Berry Hill Pond	9.00 (1)	9.76 (45)	10.00 (32)	10.00 (6)	---	---	0.8818	0.17
Thomas' Pond	10.00 (2)	9.84 (47)	9.98 (56)	---	---	---	0.1415	0.89
Stephen's Pond[1].	9.00 (1)	9.74 (28)	9.94 (71)	10.00 (3)	9.00 (1)	---	0.8980	0.14
Angle Pond.[2].	9.50 (6)	10.05 (42)	9.83 (57)	10.25 (4)	10.00 (1)	---	0.8180	0.25
Big Bear Cave Pond	9.00 (2)	9.89 (77)	10.45 (32)	10.44 (9)	11.00 (2)	---	0.9530	0.0096**
Indian Bay Big Pond	--	10.00 (6)	10.23 (61)	10.71 (24)	10.75 (8)	11.00 (1)	0.9722	0.0032**
Indian River (Stream-resident)	--	9.73 (40)	9.83 (35)	9.60 (5)	---	---	0.6000	0.49
Indian River (Sea-run)	--	---	10.00 (2)	10.43 (7)	9.80 (10)	10.00 (1)	0.31	0.75
GRAND TOTALS	9.42 (12)	9.85 (285)	10.02 (346)	10.40 (58)	10.23 (22)	10.50 (2)	0.9305	0.004*

** sig. linear correlation
* sig. non-linear correlation
1. disregarding age V+.
2. disregarding age V+.

Table VII: 6. shows the relationship between total gill raker number and age. In all areas except Angle Pond and Indian River, significant linear correlations are indicated. The coefficients are also high for Angle Pond and Indian River but are not significant. Increasing the sample size would probably result in a significant correlation for these two areas also. Combining all areas results in a very strong overall correlation ($P = 0.0007$).

Table VII: 7. shows the relationship between upper limb gill raker number and age. The correlation would not appear to be as strong as for total number. However, Berry Hill Pond, Thomas' Pond, and Stephen's Pond show significant linear correlations. When the areas are combined the overall correlation is, however, significant ($p = 0.0002$).

The correlation of lower limb gill raker number and age is given in Table VII: 8, and only two areas, Indian Bay Big Pond and Big Bear Cave Pond, show significant correlations. Combining the areas, however, again gives an overall significant correlation ($p = 0.004$).

This would indicate that the increase in gill raker number with age is due to slight increases in both upper and lower limb counts which are accentuated when total counts are considered.

It is therefore recommended that meristic comparisons of speckled trout populations based on gill raker counts be made only with fish of the same size which necessitates large samples.

2. Variation with Sex.

Wilder (1947, 1952) comparing anadromous and non-anadromous Atlantic salmon and speckled trout suggests no sexual difference could be detected in his meristic data which included gill raker counts.

The comparison of gill raker counts between sexes is given in Tables VII: 9-11.

Table VII: 9. compares total counts and shows no significant sexual dimorphism.

The upper limb counts are compared between sexes in Table VII: 10. Indian Bay Big Pond shows a significantly higher count for males ($p = 0.03$), however, the degree of significance is not high and such an isolated case of difference is not thought to represent a sexual dimorphism. Differential growth in favour of females would perhaps explain the difference, but such a difference does not exist.

Table VII: 11. gives the comparisons of lower limb counts between sexes and no difference exists.

It is therefore safe to say that no sexual dimorphism is exhibited in gill raker counts and as Wilder (1952) found for Moser River speckled trout, no bias is introduced in combining the sexes.

3. Variation with Locality

Gill rakers are generally regarded as the most stable of the meristic characters used in the Coregonidae and are generally considered the least affected by the environment (Scott and Crossman, 1964). The usefulness of this meristic character for the Salmonidae is doubtful (Vladykov, 1954), although McPhail (1961) questions the validity of Vladykov's criticism. Nevertheless, several workers have attempted to separate races of populations of several salmonid species.

McGregor (1923) concluded for the king salmon (Oncorhynchus tshawytscha) that "the results of our studies of the ... gill rakers ... would appear to

TABLE VII: 9. Comparison of total gill raker counts between sexes for speckled trout from various localities in Newfoundland.

LOCALITY	Sex	Mean Gill Raker No.	S.D.	S.E.	P. value
Berry Hill Pond	male	16.3207 (53)	.6992	.0960	0.11
	female	16.6129 (31)	.8811	.1582	
Thomas' Pond	male	16.8478 (46)	.9179	.1353	0.79
	female	16.8035 (56)	.6986	.0933	
Stephen's Pond	male	16.5365 (41)	.7105	.1109	0.48
	female	16.4354 (62)	.7382	.0937	
Big Bear Cave Pond	male	17.0000 (53)	1.1650	.1600	0.084
	female	16.6363 (66)	1.1030	.1357	
Indian Bay Big Pond	male	17.7413 (58)	1.1090	.1456	0.53
	female	17.8809 (42)	1.0720	.1654	
Angle Pond	male	16.6304 (46)	.7982	.1176	0.87
	female	16.6610 (59)	1.0100	.1314	
Indian River (Stream)	male	16.4423 (52)	.7493	.1039	0.36
	female	16.6071 (28)	.7831	.1479	
Indian River (Sea-run)	male	16.7777 (9)	.8344	.2781	0.06
	female	17.4545 (11)	.7550	.2276	
GRAND TOTALS	male	16.8128 (358)	1.0150	.0536	0.87
	female	16.8000 (355)	1.0390	.0551	

TABLE VII: 10. Comparison of upper limb gill raker counts between sexes for speckled trout from various localities in Newfoundland.

LOCALITY	Sex	Mean Upper limb count	S.D.	S.E.	P value
Berry Hill Pond	male	6.5283 (53)	.5745	.0789	0.45
	female	6.6451 (31)	.7075	.1270	
Thomas' Pond	male	6.9130 (46)	.6929	.1021	0.86
	female	6.8928 (56)	.4123	.0550	
Stephen's Pond	male	6.6829 (41)	.5215	.0814	0.22
	female	6.5483 (62)	.5633	.0715	
Big Bear Cave Pond	male	6.7924 (53)	.6000	.0824	0.16
	female	6.6515 (66)	.5682	.0699	
Indian Bay Big Pond	male	7.3448 (58)	.5191	.0681	0.03*
	female	7.5952 (42)	.5868	.0905	
Angle Pond	male	6.7173 (46)	.5441	.0802	0.67
	female	6.7627 (59)	.5356	.0697	
Indian River (Stream)	male	6.6923 (52)	.5102	.0707	0.20
	female	6.8214 (28)	.3868	.0730	
Indian River (Sea-run)	male	6.8888 (9)	.6017	.2005	0.17
	female	7.2727 (11)	.6442	.1942	
GRAND TOTALS	male	6.8240 (358)	.6150	.0325	0.83
	female	6.8338 (355)	.6279	.0333	

* significant at a probability of 0.05.

TABLE VII: 11. Comparison of lower limb gill raker counts between sexes for speckled trout from various localities in Newfoundland.

LOCALITY	Sex	Mean Lower Limb Count	S.D.	S.E.	P. Value
Berry Hill Pond	male	9.7924 (53)	.4902	.0673	0.13
	female	9.9677 (31)	.5464	.0981	
Thomas' Pond	male	9.9347 (46)	.6108	.0900	0.83
	female	9.9107 (56)	.5143	.0687	
Stephen's Pond	male	9.8536 (41)	.5273	.0823	0.73
	female	9.8870 (62)	.4092	.0519	
Big Bear Cave Pond	male	10.2075 (53)	.8403	.1154	0.14
	female	9.9848 (66)	.8131	.1000	
Indian Bay Big Pond	male	10.3965 (58)	.9274	.1217	0.50
	female	10.2857 (42)	.7303	.1126	
Angle Pond	male	9.9130 (46)	.5897	.0869	0.98
	female	9.9152 (59)	.8364	.1088	
Indian River (Stream)	male	9.7500 (52)	.5534	.0767	0.79
	female	9.7857 (28)	.5643	.1066	
Indian River (Sea-run)	male	9.8888 (9)	.3297	.1099	0.057
	female	10.1818 (11)	.3610	.1088	
GRAND TOTALS	male	9.9888 (358)	.7060	.0373	0.69
	female	9.9690 (355)	.6260	.0385	

support the belief that the Klamath and Sacramento races of king salmon possess anatomical differences of sufficient magnitude to enable careful workers to recognize the individuals of the same races".

Parker (1943) and Townsend (1944) have suggested gill rakers are of little use in differentiating races of the king salmon in California and in the Columbia River because of the degree of overlapping in counts between samples.

Pritchard (1945) also found that the degree of overlapping made it impossible to distinguish races of the pink salmon (O. gorbusca) in British Columbia.

Belding (1936) used gill raker counts of Atlantic salmon parr from various Newfoundland west coast localities and found no appreciable difference in the several rivers studied.

The comparison of total counts and counts from each limb separate is given in Tables VII: 12 -14, and are presented in the manner of Hubbs and Hubbs (1953) in Figures VII: 3-5.

The means not only differ between widely separated areas but within a given geographic area.

As an example, consider Figure VII: 3, which compares total counts between areas. The method of Hubbs and Hubbs (1953) illustrates whether means are significant or not and "t tests" were used to determine the probability. It is seen that Stephen's Pond and Thomas' Pond, both on the Avalon Peninsula, are significantly different ($p = 0.0000$) as well as the two Indian River samples ($p = 0.0022$).

The same trend is shown when both upper and lower limb counts are considered (Figures VII: 4-5).

TABLE VII: 12. Variation in the total gill raker count for speckled trout from various localities in Newfoundland, and for the Nova Scotia hatchery trout.

LOCALITY and LATITUDE	TOTAL NUMBER OF GILL RAKERS											
	14	15	16	17	18	19	20	21	Mean	No.	S.D.	S.E.
Berry Hill Pond 47° 05'	--	9	35	36	3	1	--	--	16.4285	84	0.6043	0.0848
Thomas' Pond 47° 21'	--	5	26	55	14	2	--	--	16.8235	102	0.7985	0.0790
Stephen's Pond 47° 21'	--	8	43	48	3	1	--	--	16.4757	103	0.7259	0.0715
Angle Pond 47° 24'	1	9	34	45	14	2	--	--	16.6476	105	0.9183	0.0915
Big Bear Cave Pond - 49° 07'	1	11	39	38	22	6	2	--	16.7983	119	1.1250	0.1031
Indian Bay Big Pond - 49° 04'	--	1	10	30	31	24	3	1	17.8000	100	1.1010	0.1101
Indian River (Stream) 49° 27'	--	8	29	38	5	--	--	--	16.5000	80	0.7630	0.0853
Indian River (Sea-run) 49° 27'	--	1	2	11	5	1	--	--	17.1500	20	0.8736	0.1953
GRAND TOTALS	2	52	218	301	97	37	5	1	16.8064	713	1.0080	0.0377
Nova Scotia (Hatchery trout)	--	9	26	30	4	1	--	--	16.4571	70	0.8444	0.1009

TABLE VII: 13. Variation in the upper limb gill raker count for speckled trout from various localities in Newfoundland, and for Nova Scotia Hatchery trout.

LOCALITY and LATITUDE	Number of upper limb gill rakers								
	5	6	7	8	9	Mean.	No.	S.D.	S.E.
Berry Hill Pond 47° 05'	--	41	39	3	1	6.5714	84	0.6224	0.0679
Thomas' Pond 47° 21'	--	19	76	5	2	6.9019	102	0,5612	0.0555
Stephen's Pond 47° 21'	--	44	56	3	--	6.6019	103	0.5505	0.0542
Angle Pond 47° 24'	2	26	74	3	--	6.7428	105	0.5350	0.0521
Big Bear Cave Pond 49° 07'	--	42	69	8	--	6.7142	119	0.5826	0.0534
Indian Bay Big Pond 49° 04'	--	1	55	42	2	7.4500	100	0.5550	0.0555
Indian River (Stream) 49° 27'	--	22	57	1	--	6.7375	80	0.4729	0.0528
Indian River (Sea-run)	--	3	12	5	--	7.1000	20	0.6407	0.1432
GRAND TOTALS	2	198	438	70	5	6.8288	713	0.6225	0.0233
Nova Scotia (Hatchery trout)	--	9	57	3	1	6.9428	70	0.4780	0.0571

TABLE VII: 14. Variation in the lower limb gill raker counts for speckled trout from various localities in Newfoundland, and for Nova Scotia Hatchery trout.

LOCALITY and LATITUDE	Number of lower limb gill rakers								
	8	9	10	11	12	Mean	No.	S.D.	S.E.
Berry Hill Pond 47° 05'	--	18	60	6	--	9.8571	84	0.5186	0.0565
Thomas' Pond 47° 21'	--	20	70	12	--	9.9215	102	0.5554	0.0549
Stephen's Pond 47° 21'	--	18	80	5	--	9.8737	103	0.2992	0.0294
Angle Pond 47° 24'	2	25	60	16	2	9.9142	105	0.7394	0.0721
Big Bear Cave Pond 49° 07'	3	21	64	25	6	10.0840	119	0.8240	0.0755
Indian Bay Big Pond 49° 04'	1	14	42	35	8	10.3500	100	0.8558	0.0855
Indian River (Stream) 49° 27'	--	24	51	5	--	9.7625	80	0.5589	0.0624
Indian River (Sea-run) 49° 27'	--	2	15	3	--	10.0500	20	0.4972	0.1111
GRAND TOTALS	6	142	442	107	16	9.9789	713	0.6875	0.0257
Nova Scotia (Hatchery trout)	3	29	37	1	--	9.5142	70	0.6077	0.0726

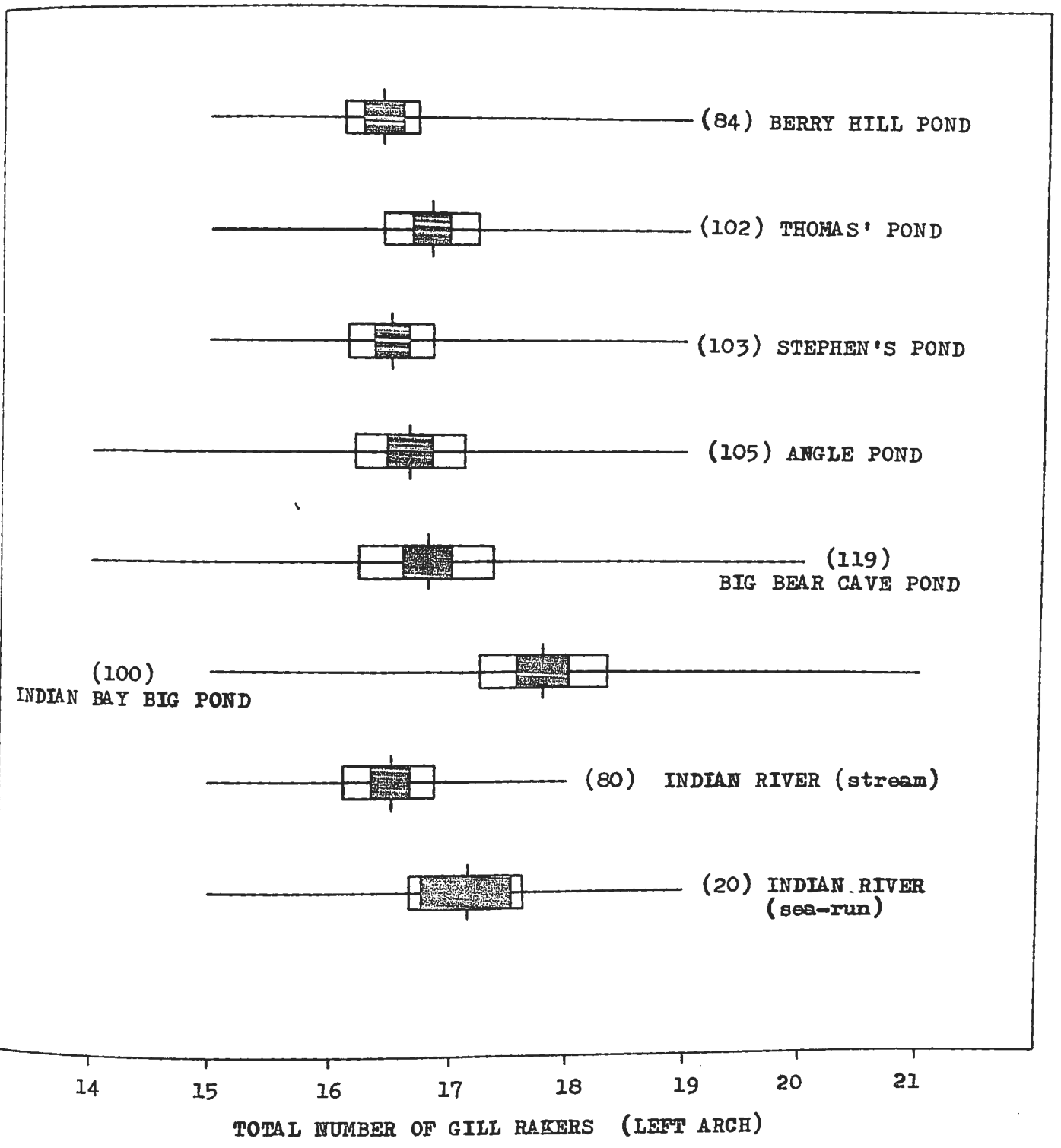


FIGURE VII: 3. Graphical comparison of total gill raker counts for speckled trout from various Newfoundland localities.

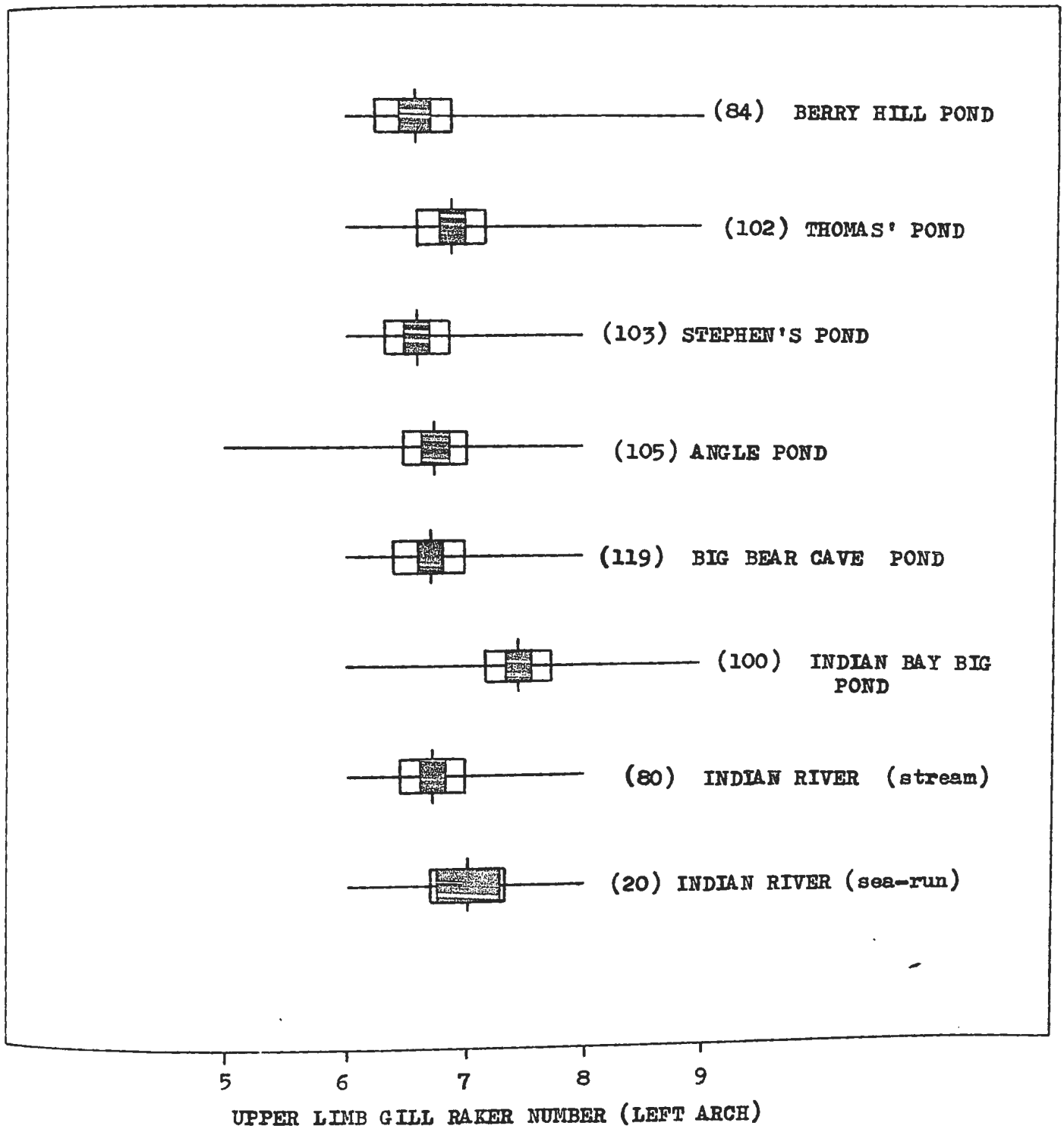


FIGURE VII: 4. Graphical comparison of upper limb gill raker counts for speckled trout from various Newfoundland localities.

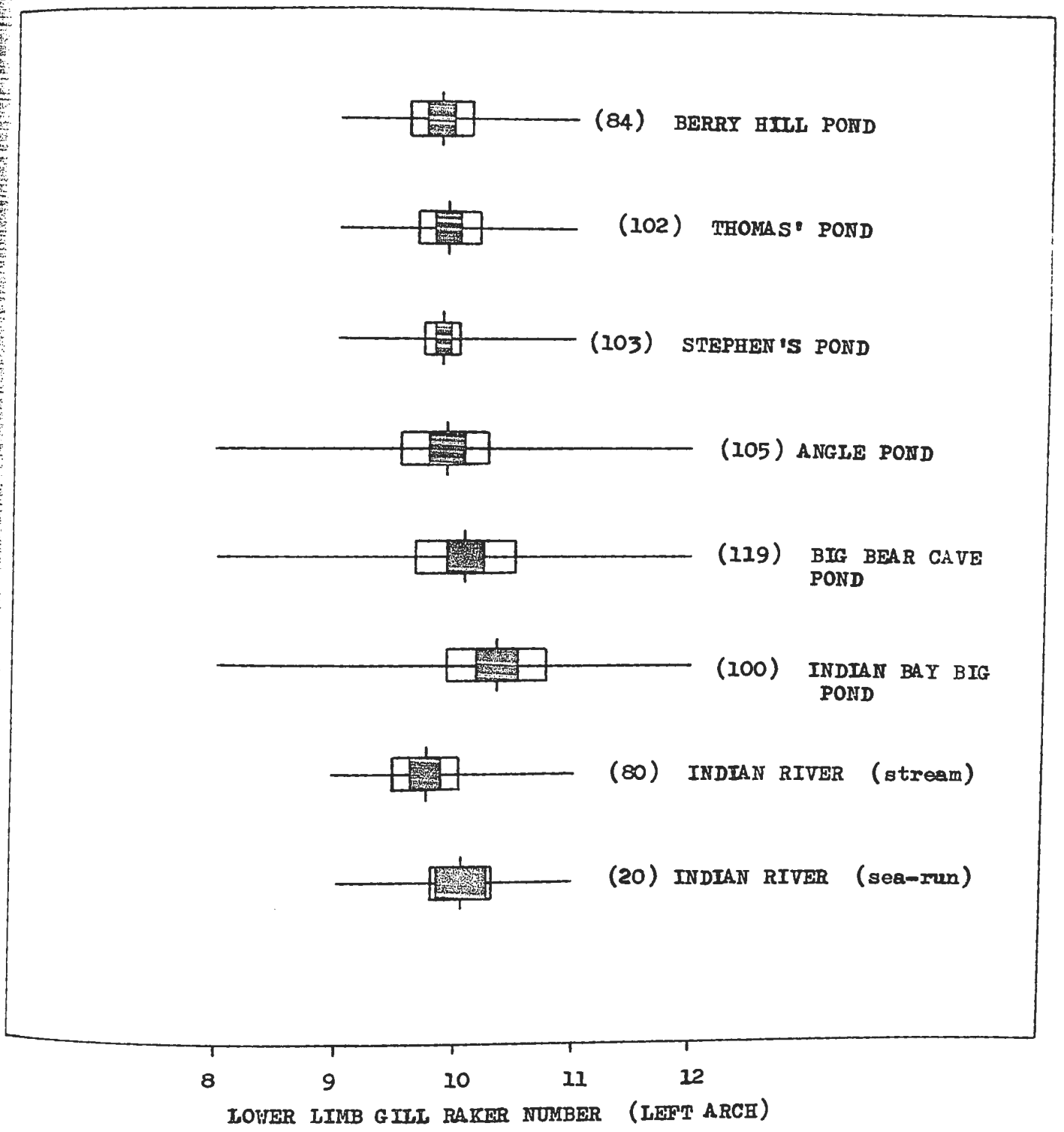


FIGURE VII: 5. Graphical comparison of lower limb gill raker counts for speckled trout from various Newfoundland localities.

Because there is such a wide variation within geographic areas, it is felt that this character is of little value for speckled trout with respect to comparison between geographic areas, and so no attempt was made to compare gill raker counts geographically.

The wide variation is undoubtedly due to the strong correlation with length and perhaps the fact that gill rakers may not be stable and very easily influenced by a number of environmental factors.

4. Comparison of Newfoundland Counts with those of other North American localities

As was already stated, Bigelow et al. (1963) suggest the range is 11-17 for total counts.

Slastenenko (1958) gives the range for Canadian waters as 11-22 total gill rakers.

Vladykov (1954) gives a range of 16-22 and a mean of 17.7 for 50 Quebec trout.

Wilder (1952) for 382 Nova Scotia trout, gives a range of 13-21 and a mean of 17.2 total gill rakers.

Scott and Crossman (1964) give a range of 15-19 and a mean of 16.8 for 30 Oliver's Brook speckled trout (Newfoundland). In this study, 713 trout gave a mean total count of 16.8 with a range of 14-21 total gill rakers.

It would therefore appear that the Newfoundland counts are somewhat lower than those of the other areas of Canada. The answer probably lies in the fact that a slower growth rate produces fewer large trout in this Province and perhaps a lower mean size all round. The correlation with size would tend to produce fewer gill rakers. This is perhaps best illustrated when we

consider the sample of Nova Scotia hatchery trout (Table VII: 12). The total count for Newfoundland is significantly higher than the count for the hatchery trout ($p = 0.00056$). However, the count for the hatchery trout is based on a sample composed entirely of two year old fish. This count is remarkably similar to counts for Newfoundland trout of the same approximate age composition and size (Berry Hill Pond, Indian River stream trout, and Stephen's Pond).

D. FIN RAY COUNTS

In using fin ray counts all rays were counted in a manner prescribed by Hubbs and Lagler (1964). The counts were made on anal and dorsal rays with both rudimentary (unbranched) and principal rays being counted. The last ray of both dorsal and anal fins, although usually divided at the base, was counted as a single ray.

The fins were clipped at the base, and the rays were stained with alizarin red. The counts were made with the aid of a dissecting microscope.

Counts were made for Berry Hill Pond and Indian River.

Vladykov (1954) suggests the number of fin rays is the meristic character of least value in char. He suggests the confusion and difficulty with counts of branched and unbranched rays is the reason.

Kendall (1914) counted only "fully developed" rays; however, Vladykov points out there is no definition of a fully-developed ray. Other authors use only branched rays but Vladykov (1954) shows that the number of branched rays in younger fish is less than in older individuals.

1. Dorsal Fin Ray Counts

(a) Variation with Age (Length)

The relationship between the number of dorsal fin rays and age is given in Table VII: 15. There is a significant linear correlation only for Berry Hill

TABLE VII: 15. Correlation of dorsal fin ray counts with age for speckled trout from various localities in Newfoundland.

LOCALITY	Average number of dorsal rays AGE (Years)							
	I+	II+	III+	IV+	V+	VI+	r.	p.
Berry Hill Pond	11.00 (1)	11.43 (45)	11.66 (32)	11.83 (6)	---	---	0.9770	0.025**
Indian River (Stream-resident)	---	11.80 (40)	11.91 (35)	11.40 (5)	---	---	0.7384	0.34
Indian River (Sea-run)	---	---	11.00 (2)	11.57 (7)	11.50 (10)	12.00 (1)	0.9264	0.10
GRAND TOTALS	11.00 (1)	11.60 (85)	11.77 (69)	11.61 (18)	11.50 (10)	12.00 (1)	0.7240	0.11

** sig. linear correlation.

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Pond ($p = 0.025$). When the samples are combined there is no significant correlation ($p = 0.11$). This weak relationship is probably due to the fact that more branched rays are present in larger fish, and perhaps because the small simple rays are more easily overlooked in small fish. Wilder (1947) suggests no such relationship with size or age exists in Atlantic salmon.

(b) Variation with Sex

The dorsal fin ray counts are compared with respect to sex in Table VII: 16.

TABLE VII: 16. Comparison of Dorsal Fin ray counts between sexes for speckled trout from various localities in Newfoundland.

LOCALITY	Sex	Mean Dorsal Fin rays	S.D.	S.E.	P value
Berry Hill Pond	male	11.4905 (53)	.5046	.0693	0.27
	female	11.6333 (30)	.6147	.1122	
Indian River (Stream)	male	11.8653 (52)	.5281	.0732	0.34
	female	11.7500 (28)	.5157	.0974	
Indian River (Sea-run)	male	11.5555 (9)	.5232	.1744	0.43
	female	11.4545 (11)	.5196	.1566	
GRAND TOTALS	male	11.6666 (114)	.5442	.0509	0.87
	female	11.6521 (69)	.5620	.0676	

No evidence of sexual dimorphism is present, and no apparent bias is introduced in combining the sexes, as was also reported by Wilder (1952).

(c) Variation with Locality

A comparison of dorsal rays between localities is given in Table VII: 17. The count for Berry Hill Pond is significantly lower than for Indian River (stream trout) with a probability of 0.0003. The two Indian River counts also differ with Indian River sea trout having a lower count than the stream-resident fish ($p = 0.011$). Where the two Indian River counts were combined they were significantly higher than the Berry Hill Pond count ($p = 0.0072$).

TABLE VII: 17. Variation in the dorsal fin ray counts of speckled trout from various localities in Newfoundland.

LOCALITY and LATITUDE	Number of dorsal rays							
	10	11	12	13	Mean.	No.	S.D.	S.E.
Berry Hill Pond 47° 05'	1	37	44	1	11.5421	83	0.5463	0.0599
Indian River (Stream) 49° 27'	--	19	56	5	11.8250	80	0.5199	0.0581
Indian River (Sea-run) 49° 27'	--	10	10	--	11.5000	20	0.5129	0.1153
GRAND TOTALS	1	66	110	6	11.6612	183	0.5536	0.0409

The difference in count between Berry Hill Pond and Indian River may be a latitudinal one, with the lower count (Berry Hill Pond) at the lower latitude. Andrews and Lear (1956) found a difference with latitude for arctic char in Labrador.

Wilder (1952) found that more dorsal rays were produced at the higher of two incubation temperatures for speckled trout. Tåning (1952), using the brown trout, found however, that the general rule of highest counts at intermediate temperatures and lowest counts at the two extremes of the temperature range held. This U-shaped distribution in relation to water temperature has never been encountered in nature where we usually get a negative correlation

between temperature and meristic count. The reason for this is not yet apparent, but there are possibly other environmental factors in nature which are not apparent in laboratory experiments.

The difference in count between the Indian River sea and fresh water trout is perhaps due to small sample size.

Wilder (1952) found no differences between various areas for Nova Scotia trout.

(d) Comparison of Newfoundland Counts with those of other North American Localities

Bigelow et al. (1963) give the range for dorsal rays as 11-14.

Slastenonko (1958) gives 11-15 as the range for Canadian waters.

Norden (1961) gives a range of 11-14 rays for Michigan trout.

Wilder (1952) gives a range of 10-14 rays and a mean of 12.01 for 455 Nova Scotia trout.

Vladykov (1954) reports a range for Quebec trout as 9-12 rays with a mean of 10.3 for 22 trout.

In this study for 183 trout, the range was 10-13 rays with a mean of 11.66 rays.

In all instances, the counts are total counts and there would appear to be no consistent latitudinal difference.

2. Anal Fin Ray Counts

(a) Variation with Length or Age

The relationship between the number of anal fin rays and age is given in Table VII: 18. There is no significant correlation for either of the

TABLE VII: 18. Correlation of anal fin ray counts with age for speckled trout from various localities in Newfoundland.

LOCALITY	AVERAGE NUMBER OF ANAL RAYS AGE (Years)							
	I+	II+	III+	IV+	V+	VI+	r.	p.
Berry Hill Pond	10.00 (1)	10.51 (45)	10.72 (32)	10.83 (6)	---	---	0.9429	.076
Indian River (Stream-resident)	---	10.65 (40)	10.66 (35)	10.20 (5)	---	---	0.8500	.21
Indian River (Sea-run)	---	---	10.50 (2)	11.00 (7)	10.80 (10)	12.00 (1)	0.2580	.79
GRAND TOTALS	10.00 (1)	10.58 (85)	10.68 (69)	10.72 (18)	10.80 (10)	12.00 (1)	0.8720	.02*

* sig. non-linear correlation.

localities, however when the data are combined a significant non-linear correlation was found between the number of anal rays and age ($p = 0.02$). The fact that no significant correlation was found for either of the two areas, but for the combined data, indicates at best only a weak relationship. The reason is perhaps as for dorsal rays; the difficulty in counting unbranched rays in small fish.

(b) Variation with Sex

The anal fin ray counts for both sexes are compared in Table VII. 19. As with dorsal rays, no evidence of sexual dimorphism is found, and no apparent bias is introduced in combining the sexes. Wilder (1952) reports no evidence of sexual dimorphism in anal fin ray counts for Nova Scotia trout.

(c) Variation with Locality

The counts for the two Indian River samples and Berry Hill Pond are given in Table VII: 20, and are compared graphically in Figure VII: 6. The use of "t tests" indicates that Indian River stream trout and sea trout are significantly different at a probability of 0.044, while Berry Hill Pond trout and Indian River sea trout are also different ($p = 0.032$).

The differences may be due to the small sample number and larger size of the sea trout. Berry Hill Pond trout and Indian River stream trout, which are widely separated geographically, are not significantly different ($p = 0.74$). When the two Indian River counts are combined they do not differ from the count for Berry Hill Pond ($p = 0.36$). It would appear, therefore, that no consistent latitudinal difference exists.

Wilder (1952) found no difference in anal ray counts for speckled trout from various Nova Scotia localities.

Andrews and Lear (1956), however, found latitudinal variation for Labrador arctic char.

(d) Comparison of Newfoundland Counts with those of other North American Localities

Bigelow et al. (1963) give 9-12 as the range for anal fin rays.

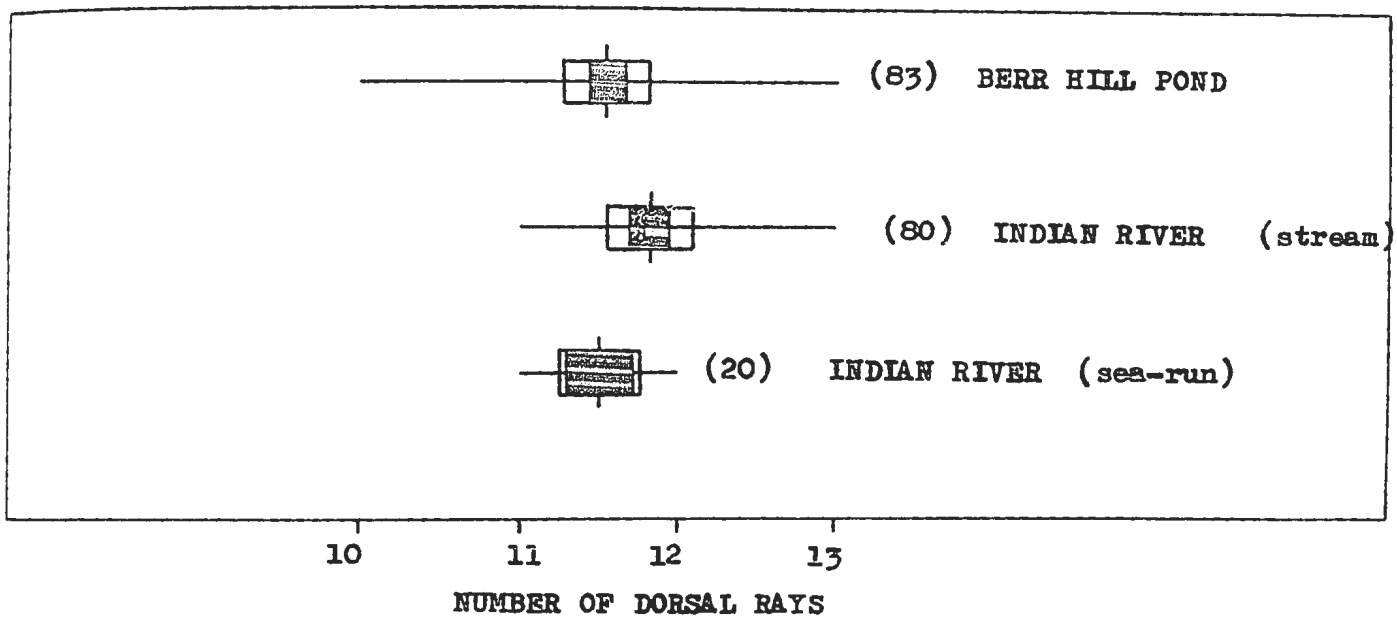
Slastenenko (1958) gives the range for Canadian speckled trout as 10-14 rays.

TABLE VII: 19. Comparison of Anal Fin ray counts between sexes for speckled trout from various localities in Newfoundland.

LOCALITY	Sex	Mean Anal Fin Rays	S.D.	S.E.	p value
Berry Hill Pond	male	10.5849 (53)	.5382	.0739	0.62
	female	10.6451 (31)	.5577	.1001	
Indian River (Stream-resident)	male	10.6346 (52)	.5254	.0728	0.83
	female	10.6071 (28)	.5650	.1067	
Indian River (Sea-run)	male	10.7777 (9)	.6680	.2226	0.39
	female	11.0000 (11)	.4472	.1348	
GRAND TOTALS	male	10.6228 (114)	.5345	.0500	0.45
	female	10.6857 (70)	.5563	.0664	

TABLE VII: 20. Variation in the anal fin ray counts of speckled trout from various localities in Newfoundland.

LATITUDE & LOCALITY	NUMBER OF ANAL RAYS 10	11	12	Mean	No.	S.D.	S.E.
Berry Hill Pond 47° 05'	35	47	2	10.6071	84	0.5361	0.0584
Indian River (Stream) 49° 27'	32	46	2	10.6250	80	0.5325	0.0595
Indian River (Sea-run) 49° 27'	4	14	2	10.9000	20	0.5525	0.1235
GRAND TOTALS	71	107	6	10.6467	184	0.5410	0.0398



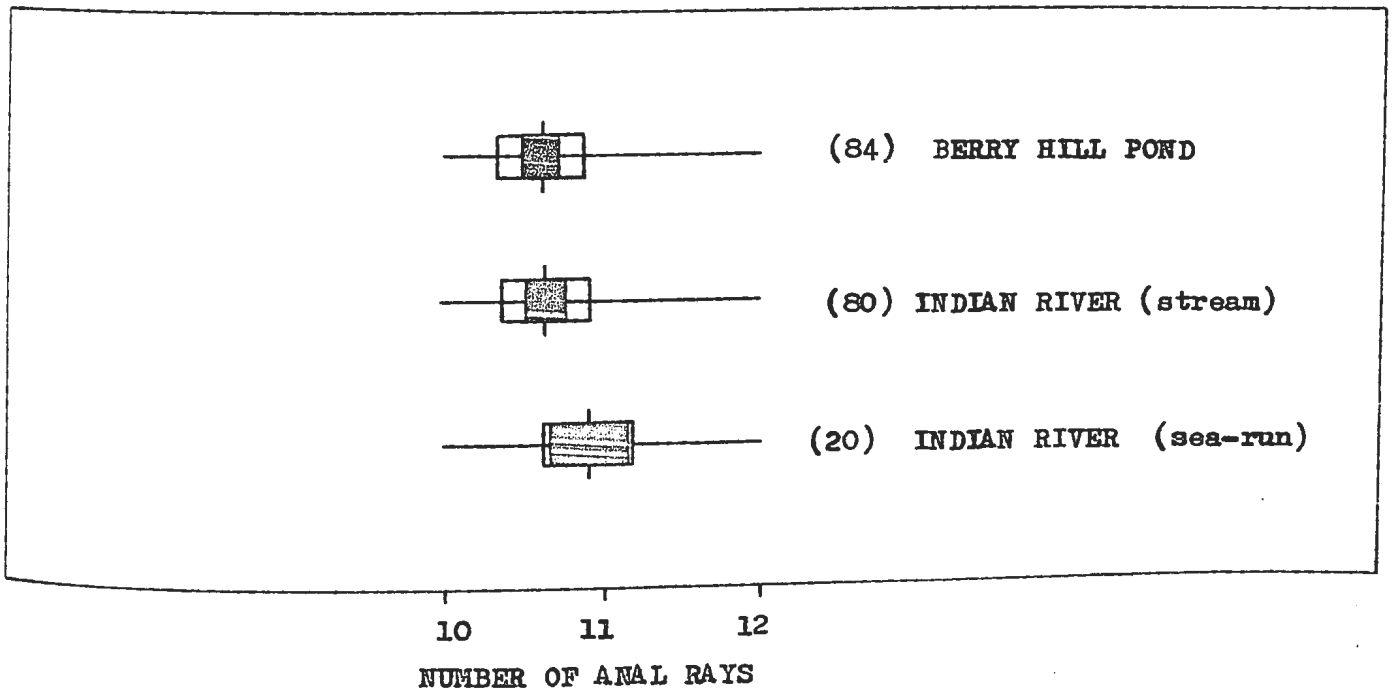


FIGURE VII: 6. Graphical comparison of dorsal and anal ray counts for speckled trout from various Newfoundland localities.

Vladykov (1954) gives the range for 22 Quebec trout as 8-11 rays, with an average of 9.5.

Wilder (1952) reports the range for 455 Nova Scotia trout as 9-12 with a mean of 10.89 rays.

In this study the range for 184 trout was 10-12 with a mean of 10.65 rays.

As was the case for dorsal fin rays, there does not appear to be any consistent latitudinal variation.

E. Comparison of Freshwater Trout and Sea Trout

Most members of the Salmonidae have both an anadromous and non-anadromous form. The close affinity of the two forms has long been recognized but the exact systematic status is a question of much speculation.

Landgrebe (1941) suggests that the anadromous and non-anadromous forms of brown trout are genetically distinct.

Neave (1943) suggests the non-anadromous rainbow trout and steelhead differ in the number of scale rows and are genetically different.

Wilder (1947), using body measurements and meristic counts concludes that the Atlantic salmon and lake salmon (landlocked salmon) do not differ inherently.

Jordan and Evermann (1896), Kendall (1914), and Bigelow and Welsh (1925) all consider the sea trout and fresh water trout to be identical.

Hubbs (1926), however, believes the sea trout is racially distinct from the fresh water trout.

Wilder (1952) carried out a comprehensive study using color, body measurements, and meristic counts and concludes there is no genetic difference between the two forms.

In this study the Indian River area provided an opportunity to compare the meristics of the two forms, with vertebrae, gill rakers, anal and dorsal rays being compared.

Table VII: 21 compares the meristic counts of sea-run and stream-resident trout, and gives the probabilities for significant differences.

Vertebral averages show a remarkable similarity ($p = 0.87$), however, sea trout have a higher total gill raker count ($p = 0.002$); a higher anal fin ray count ($p = 0.044$); and a lower dorsal fin ray count ($p = 0.011$).

The difference in the number of total gill rakers is explained by the fact that the larger sea trout would have a higher count because of the strong correlation of gill raker number with size.

Because fin rays are suggested by Vladykov (1954) to be the least useful of the meristic characters, and because high variability may result from the counting of rudimentary rays, the differences between the two forms of trout are accepted without too much significance.

Wilder (1952) used branchiostegal rays, gill rakers, pelvic fin rays, pectoral fin rays, dorsal and anal fin rays, and vertebrae and found no significant differences for any of these characters between fresh water and sea trout of Moser River, Nova Scotia.

Scott and Crossman (1964) suggest, however, that fresh run sea trout have proportionally larger pectoral and pelvic fins, and less pyloric caeca than fresh water trout. This is in direct contrast to Wilder (1952) who suggests sea trout have "comparatively small head parts and fins".

From the small amount of data used in this study, it is not possible to draw any clear cut conclusion regarding the affinity of the two forms of speckled trout.

TABLE VII: 21. Comparison of meristic counts between sea-run and stream-resident speckled trout for Indian River.

Meristic Character	Form of Trout	Mean	S.D.	S.E.	p value
Vertebrae	Sea-run	59.4500 (20)	0.7574	0.1693	0.87
	Stream-resident	59.4175 (91)	0.9455	0.0991	
Gill Rakers (Total)	Sea-run	17.1500 (20)	0.8736	0.1953	0.0022**
	Stream-resident	16.5000 (80)	0.7630	0.0853	
Dorsal rays	Sea-run	11.5000 (20)	0.5129	0.1153	0.011*
	Stream-resident	11.8250 (80)	0.5199	0.0581	
Anal Rays	Sea-run	10.9000 (20)	0.5525	0.1235	0.044*
	Stream-resident	10.6250 (80)	0.5325	0.0595	

* significant at a probability of 0.05.

** significant at a probability of 0.01.

VIII. SEX AND SEXUAL MATURITY

In an examination of the life cycle of a fish, there are several key stages or phases to which our attention is immediately drawn, perhaps the most important of which is reproduction.

Speckled trout populations generally are quite resilient, despite heavy exploitation by anglers and heavy reduction by other natural and unnatural causes. It is therefore of considerable importance to have knowledge concerning the reproductive ability of such populations, as several authors (Rounsefell and Kelez, 1938; and Rounsefell, 1949) point out, there is a relationship between the reproductive potential of the spawning stocks and the numbers of young surviving.

In such a consideration of reproductive ability, we are concerned with several aspects: (1) sex ratios, (2) attainment of sexual maturity, (3) fecundity, and (4) natural spawning.

A. Sex Ratios

Knowledge of the sex ratio of a population is of value in estimating the numbers of potential spawning females and in determining whether a differential mortality rate exists between the sexes.

Consistent deviations of large magnitude from a 1:1 sex ratio are frequently reported for various species. The most common case is a progressive decrease in the proportion of males in older age groups (McFadden et al, 1962).

Cooper (1953) reports that in several Michigan localities, overall, females compose 55 per cent of the population.

Doan (1948) suggests that for the Nelson River, Manitoba, females compose 47 per cent of the population.

McFadden (1961) suggests the sexes are about equally represented in samples of yearling fish from Lawrence Creek, Wisconsin, but the proportion of females becomes greater in successively older age groups. McFadden, et al (1962) found no significant difference in sex ratios for brown trout.

Wydoski and Cooper (1966) found no significant deviation from the 1:1 ratio for speckled trout populations of several Pennsylvania streams.

The sex ratios for trout from the various localities studied are given in Table VIII: 1, where Chi-square tests (Hoel, 1965) are used to determine significance of differences. It is noticed that males are significantly more abundant than females at Berry Hill Pond, and Indian River (stream); while at Stephen's Pond females are significantly higher in number.

The predominance of females in the Stephen's Pond sample could be the result of differential angling mortality of faster growing males or differential natural mortality as suggested by McFadden (1961). Scott and Crossman (1964) give sex ratios for angled trout from Oliver's Brook, Newfoundland, and show a ratio of 10:3 favoring males.

The predominance of males in the samples from Berry Hill Pond and Indian River (stream) is of interest because both of these are relatively unexploited areas.

Wilder (MS) suggests that 70 per cent of the seaward migrating trout smolt of Moser River, Nova Scotia, were females. If such a differential

migration of females occurs at Indian River, this might explain the high ratio of males in mid-August after the run was over.

Berry Hill Pond which is also a relatively little exploited area also shows a preponderance of males. The only other explanation besides differential mortality would be that sampling was biased in favour of pre-spawning (late August) aggregations of males.

Table VIII: 1. also shows the sex ratio of 20 sea-run trout taken at Indian River, the ratio is almost 1:1 with 9 males and 11 females. White (1940) however, suggests that for Moser River trout, the majority of returning fish are large females. Scott and Crossman (1964) give sex ratios of sea-trout from several Newfoundland localities and the ratio as 23:15 in favor of females. This is to be expected if, as Wilder suggests, the majority of trout smolts are females.

Table VIII: 2. shows sex ratios for different age groups of speckled trout from all localities combined. Chi-square tests indicate no significant difference in ratios for either age group contrary to the suggestion by McFadden et al (1962) that in general, the preponderance of females increases in older age groups.

The sex ratio for all trout collected was 429:416 in favor of females, and the difference was not significant.

It is therefore concluded that under natural conditions, the sex ratio of 1:1 holds for speckled trout populations.

B. Attainment of Sexual Maturity

Several factors influence the first attainment of sexual maturity in fishes. Among these are differences in species, in age and size, and in

TABLE VIII: 1. Sex ratios of speckled trout from various localities in Newfoundland.

LOCALITY	Sex Ratio Male : Female	$x = n - 1 = 1$ degree of freedom X^2 value	Difference
Indian River (Stream)	59 : 36	5.56	significant at p=.05
Berry Hill Pond	54 : 30	6.86	significant at p=.01
Stephen's Pond	41 : 63	4.65	significant at p=.05
Angle Pond	48 : 62	1.78	no significance
Thomas' Pond	47 : 58	1.15	no significance
Big Bear Cave Pond	54 : 68	1.61	no significance
Indian Bay Big Pond	58 : 42	2.56	no significance
Indian River (Sea-run)	9 : 11	0.20	no significance

TABLE VIII: 2. Sex ratios of speckled trout by age groups for various localities combined.

SEX	AGE CLASS I+	II+	III+	IV+	V+	VI+	TOTAL
Male	11	145	168	79	12	1	416
Female	5	151	178	84	10	1	429
X^2 Value	2.2	0.12	0.29	0.14	0.18	0.00	0.12
Significant Difference	none	none	none	none	none	none	none

individual physiology. In general, species of small maximum size and short life span (e.g. speckled trout) mature at younger ages than do species of larger maximum size.

Once sexual maturity is attained, the sex products must ripen and reproduction must take place. Two groups of forces are at work towards this end; these are broadly intrinsic and extrinsic forces. Among the intrinsic forces are species differences, food, and individual physiology. The extrinsic factors of the external environment may be either physical, chemical or biotic.

In any study of attainment of sexual maturity, the basic division between immature and mature fish must first be established.

The basic criterion for maturity in males is the presence of sperm at that season of the year when they are to be expected. Color, gonad size, and texture are also important criteria. Fish maturing for the first time do, however, cause some trouble. Males were designated immature if the testes were very small, narrow or thread like, and showed no sign of vascularization. Maturing males had larger prominent, highly vascularized testes. Prior to, and during spawning, differentiation was simple as the presence of milt in mature fish gave the testes a creamy-white appearance.

Separation of immature and mature females is simple when the growth phase of oocytes becomes advanced. Size of the oocytes and ovary are also important. When the gonad is quiescent, however, it is often difficult to separate immature and maturing fish.

The criteria used to designate female trout as either immature or mature were based on Vladykov (1956). Female trout were designated immature if the ovaries were very small and narrow; eggs minute with a diameter

smaller than 1 mm. This stage is termed Stage 0, or juvenile immature condition by Vladykov.

Vladykov goes on to list five further stages of maturity, all of which were taken to be indicative of a mature female in this study. The criterion used to designate a female maturing for the first time was Vladykov's Stage 1 or resting period. This is characterized by small, narrow, elongated, yellowish, more or less triangular ovaries which are rather hard. Egg diameter is around 1 mm. A female trout showing these characteristics would be designated sexually mature as it would have undoubtedly spawned during the year of capture. Trout showing characteristics of Stage 0 were designated immature and were considered not able to spawn during the year of capture.

With the approach of the spawning season, it is a simple matter to distinguish mature females from immature females on the basis of oocyte size alone.

1. Age at First Maturity

Table VIII: 3. shows the percentages of mature trout in each age group for all localities studied. The data are presented graphically in Figure VIII: 1 (a-b). It is seen that no trout of either sex from age group I^+ are sexually mature. It is also seen that, generally, males tend to mature at an earlier age than females. There would also seem to be a general trend for faster growing trout in larger bodies of water to mature at earlier ages than slower growing individuals of smaller habitat size. In four of the seven localities, 50 per cent of both sexes are sexually mature at age II^+; however, only at age III^+ are the majority of the fish

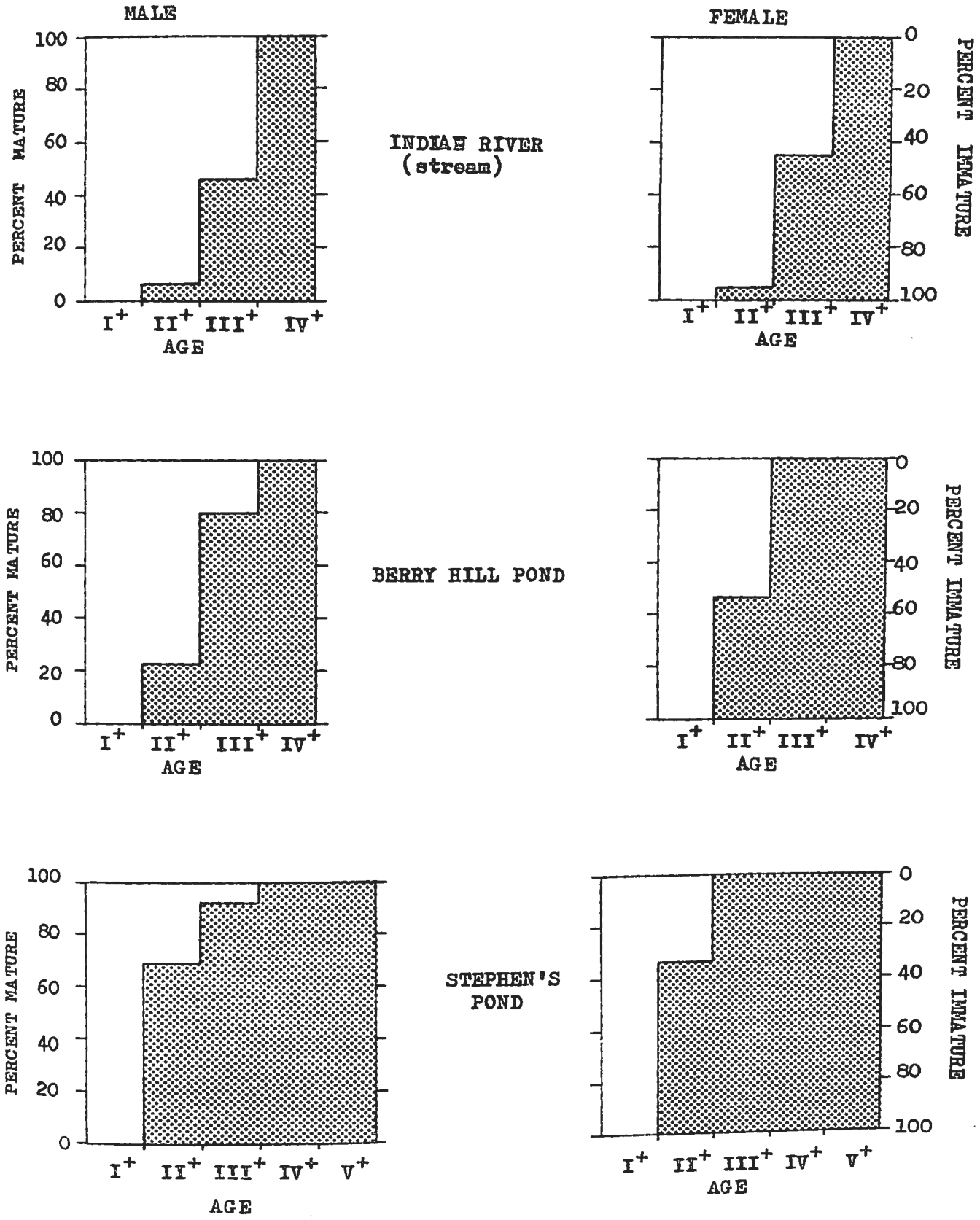


FIGURE VIII: 1.(a) Percentage of mature and immature male and female speckled trout by age class for various localities.

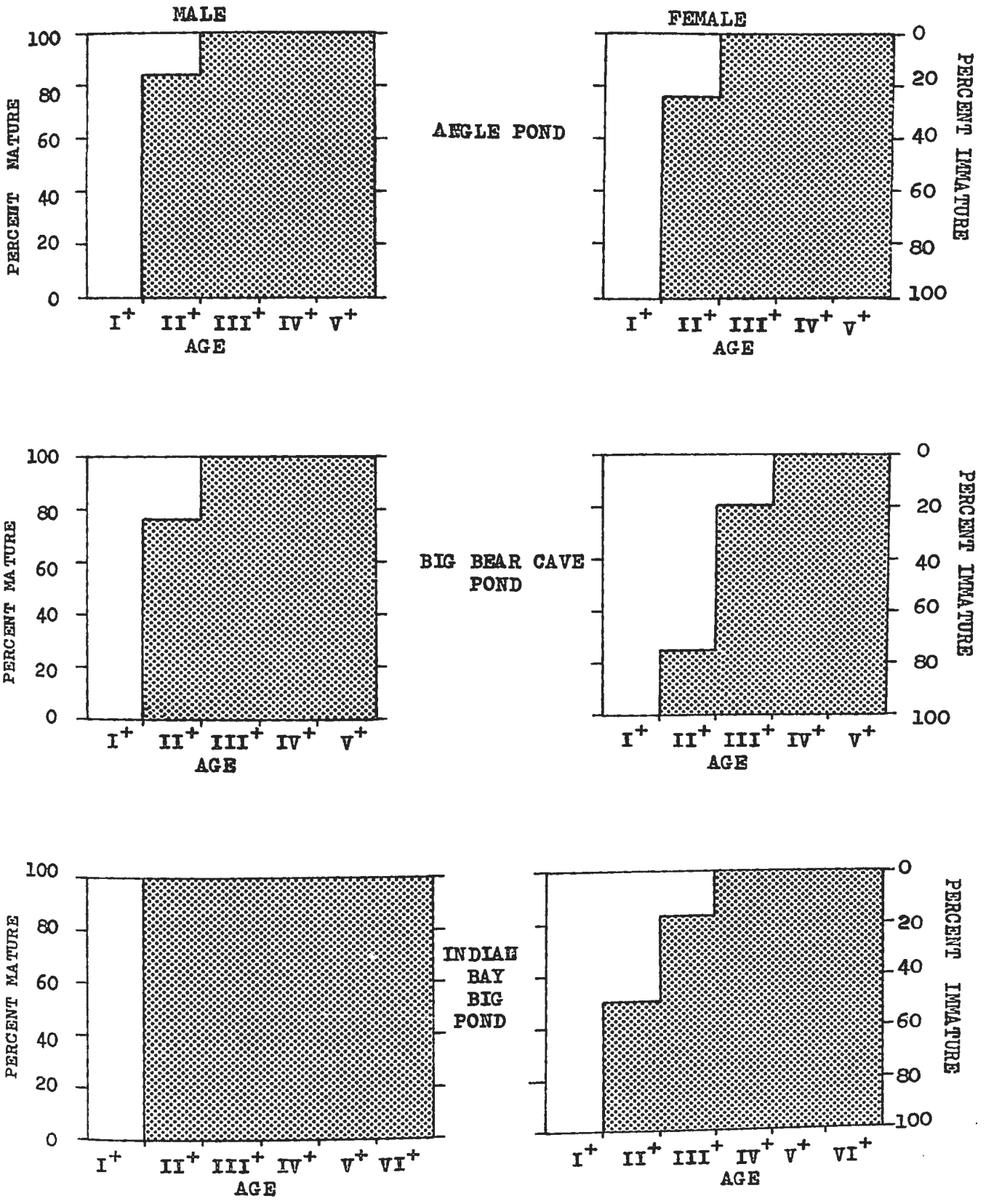


FIGURE VIII: 1. (b) Percentage of mature and immature male and female speckled trout by age class for various localities.

TABLE VIII: 3. Percentages of mature speckled trout by age class in samples from seven localities, sexes separated.

LOCALITY	SEX	AGE CLASS I+	II+	III+	IV+	V+	VI+	Number
Indian River (Stream)	male	0.0	6.5	45.8	100.0	---	---	59
	female	0.0	5.0	54.5	100.0	---	---	36
Berry Hill Pond	male	0.0	23.3	80.0	100.0	---	---	53
	female	---	46.7	100.0	100.0	---	---	31
Stephen's Pond	male	0.0	69.2	92.3	100.0	---	---	41
	female	---	66.7	100.0	100.0	100.0	---	63
Angle Pond	male	0.0	94.1	100.0	100.0	100.0	---	48
	female	0.0	76.0	100.0	100.0	---	---	62
Thomas' Pond	male	0.0	100.0	100.0	---	---	---	47
	female	---	100.0	100.0	---	---	---	58
Big Bear Cave Pond	male	0.0	76.7	100.0	100.0	100.0	---	54
	female	0.0	25.5	81.3	100.0	100.0	---	68
Indian Bay Big Pond	male	---	100.0	100.0	100.0	100.0	100.0	58
	female	---	50.0	92.9	100.0	100.0	---	42
Indian River (Sea-run)	male	---	---	100.0	100.0	100.0	100.0	9
	female	---	---	100.0	66.7	100.0	100.0	11

mature, with some not reaching maturity until age IV^+. All fish of age IV^+, V^+ and VI^+ years are sexually mature with the exception of age IV^+ years sea trout from Indian River.

Wydoski and Cooper (1966) state ... "The brook trout as a species is inherently capable of maturing and spawning at the end of its first year of life (0^+ years)." They suggest, however, that the time of maturation may be affected by many factors including heredity.

They suggest a slow rate of growth may seriously retard maturation, and conversely a growth rate exceeding the normal, may result in precocious maturation. Brasch, et al (1958) and McFadden (1961) report that 95.5 per cent of male trout of Lawrence Creek, Wisconsin, are mature at 0^+ years, and 83.0 per cent of the females are mature at age I^+ years. Under fish-cultural regimes, both sexes may mature at age 0^+ years (Seguin, 1951). Most authors (Ricker, 1932; Doan, 1948; Benson, 1953; Allen, 1956; and Wydoski and Cooper, 1966) suggest however, that few mature at age I^+; some at age II^+ and the majority at age III^+ years.

In this study, it was generally noted that males mature earlier than females; this is in general agreement with most authors (Greeley, 1932; Allen, 1956; Brasch, et al 1958; McFadden, 1961; and Wydoski and Cooper, 1966). Hoar (1957) suggests early attainment of sexual maturity by male fish may be associated with a shorter life span.

Frost (1938) suggests that at least 50 per cent of males and females in Newfoundland waters are capable of spawning at age III^+ years; she makes no mention, however, of differential attainment of maturity.

Table VIII. 3. indicates faster growing trout mature at an earlier age than slower growing individuals. This is verified by Wydoski and Cooper

(1966) for Pennsylvania trout. They suggest poor nutrition at that time of year when maturation is normally rapid may result in complete lack of development. This relationship between maturity and growth rate was also found by Alm (1959), Edsall (1960) and Fenderson (1964) for other species.

Wydoski and Cooper (1966) also suggest delayed maturation in some populations may be an inheritable characteristic. Genetic control of maturation has been reported for the brown trout by Alm (1949) and for the Arctic char by Maar (1949).

Table VIII. 3 indicates that while all male sea-run trout III^+ years and older are sexually mature, only 66.7 per cent of the females of age IV^+ years are sexually mature. This is in agreement with observations made by Huntsman (1938), White (1940), Wilder (1952) and Scott and Crossman (1964) for the sea-run speckled trout and by Menzies (1936) for the sea-run brown trout. Although it is generally considered that speckled trout spawn every year after reaching maturity (Vladykov, 1956), several authors (Ricker, 1932, and Wydoski and Cooper, 1966) suggest there may be a failure to spawn during certain years of poor growth or poor nutrition. Because sea-run trout have been shown to cease or reduce their feeding in fresh water, it would therefore not be surprising to find that spawning is postponed in some years.

Ricker (1932) concludes his discussion on maturity by suggesting "There is no known upper limit of length or age at which sexual activity ceases".

2. Size at First Maturity

Table VIII: 4 lists the calculated lengths at which both male and female trout reach sexual maturity for the first time. The point at which

TABLE VIII: 4. The mean length (cm.) at which sexual maturity is reached in speckled trout (sexes separated) from various localities.

LOCALITY	Length (cm.) at which 50% of the fish are mature	
	Male	Female
Indian River (Stream)	13.79	17.05
Berry Hill Pond	16.36	14.82
Stephen's Pond	13.55	15.19
Angle Pond	15.55	17.55
Thomas' Pond	15.55	< 16.55
Big Bear Cave Pond	15.50	18.78
Indian Bay Big Pond	< 18.55	18.55

50 per cent of the population is mature is taken as the size at first maturity. Sizes at maturity expressed as less than a certain value (e.g. < 16.55) indicates that over 50 per cent of the fish in the 16.55 cm. length class are mature and that this is the smallest size class sampled.

Generally, males mature at smaller sizes than females, with the exception of Berry Hill Pond, where females mature at a smaller size. It may have been that biased sampling selected pre-spawning and hence mature

aggregations of males as the calculated length at first maturity for males, 16.36 cm., seems high in the light of values from other areas.

It appears, therefore, that males generally not only mature at earlier ages, but also at smaller sizes.

Ricker (1932) suggests that for Ontario trout, males average an inch shorter than females on the same redd, and a male 5.6 inches (14.2 cm) in length was the smallest fish captured on the spawning grounds.

Frost (1938) reports the smallest trout taken on the spawning grounds at Murray's Pond was 5.4 inches (13.7 cm).

Vladykov (1956) suggests fish of either sex can spawn upon reaching a fork length of 13-14 cm.

These values agree quite well with calculated values in this present study.

Numerous other authors have commented on the attainment of sexual maturity by males at smaller lengths than females (Greeley, 1932; Benson, 1953; Allen, 1956; Brasch et al, 1958; McFadden, 1961; and Wydoski and Cooper, 1966).

It is difficult to ascribe any ecological significance to the relationship between size or age and the attainment of sexual maturity on the basis of the present data. It is perhaps sufficient to recognize that marked differences among populations do occur, and these are undoubtedly of significant ecological importance and that further study is greatly needed.

C. Variation of Stages of Maturity with Age

Besides the basic division of immaturity and maturity for female speckled trout, the various degrees of maturity were broken down into five

maturity stages following Vladykov (1956). The stages are somewhat arbitrary and are based on ovary size, appearance, texture, and ova size. The description of the stages is as follows (Vladykov, 1956):

Stage 1: Resting Period. Ovaries small, narrow, elongated, yellowish, more or less triangular, and rather hard. Egg diameter is around 1 mm. (Plate VIII: 1).

Stage 2: Early Development. Characteristics similar to Stage 1, but the ovaries are larger. Egg diameter is around 2 mm.

Stage 3: Active Period. Ovaries much larger. Blood vessels are easily visible on the ovary surface. Egg diameter is 2-3 mm.

Stage 4: Penultimate Period of Ripeness. Expanded ovaries occupy much of the body cavity, and their blood vessels are nearly invisible. Egg diameter is 3.5-4 mm.

Stage 5: Spawning Period. Ovaries are greatly extended, bulging with loose eggs. Slight pressure can eject ova through the genital pore. Egg diameter is 4-4.8 mm. (Plate VIII: 2).

Stage 6: Spent Condition. Ovaries are contracted, flacid, sometimes filled with a fluid. The ovaries contain a large number of minute eggs of recruitment stock, the diameter of which is less than 1 mm. (Plate VIII: 3).

PLATE VIII: 1. Stage 1 of maturity in speckled trout -- Resting Period (From Vladykov, 1956).

PLATE VIII: 2. Stage 5 of maturity in speckled trout -- Spawning Period (From Vladykov, 1956).

PLATE VIII: 3. Spent Condition in speckled trout (From Vladykov, 1956).

Tables VIII: 5(a-b) show the variation in stages of maturity with age for mature speckled trout. Berry Hill Pond and Angle Pond were chosen to represent fall and spring conditions respectively. It is seen that fish of the older age groups are generally at a higher stage of maturity than are fish of the younger age groups at any one time. This therefore implies that the older maturing trout should spawn at an earlier date than the slower maturing younger fish.

This is in agreement with Wydoski and Cooper (1966) who state "Large females in a population tend to spawn earlier than smaller females do".

Dinsmore, as reported by Greeley (1934) states that at a particular hatchery oldest fish (four years) are stripped about two weeks before two-year old fish, and yearling fish are stripped at the latest dates.

Henderson (1963) reports that she has observed several stocks of slow growing trout that were becoming functionally mature for the first time, and noted that many of the young females could not be stripped until later than older females.

Greeley (1932) reports that the spawning season is of long duration because individual fish vary in the time of arrival at spawning places, probably due to differences in time of maturity.

White (1934) suggests there is a "struggle for existence" between the early and late spawners. The early spawners have an advantage in that earlier development of fry enables them to take advantage of the abundant food supply. The disadvantage is that the redds may be disturbed by later spawners. Late spawners have an advantage in that their redds will not be disturbed.

TABLE VIII: 5a. Variation in stages of maturity with age for mature female speckled trout from Berry Hill Pond.

MATURITY STAGE	AGE CLASS			
	I^+	II^+	III^+	IV^+
1	---	(1) 14.3	---	---
2	---	(6) 85.7	(4) 33.3	---
3	---	---	(5) 50.0	(3) 75.0
4	---	---	(2) 16.7	(1) 25.0

TABLE VIII: 5b. Variation in stages of maturity with age for mature female speckled trout from Angle Pond.

MATURITY STAGE	AGE CLASS			
	I^+	II^+	III^+	IV+
1	---	(2) 10.5	(1) 2.9	---
2	---	(10) 52.6	(3) 8.8	---
3	---	(9) 36.8	(30) 88.2	(1) 100.0

The implications of variation in maturity stage with age are obvious when this "struggle for existence" is considered.

D. Fecundity

The fecundity of hatchery reared speckled trout has been reported by a number of authors including Von Bayer (1910), Kendall (1914), Hayford and Embody (1930), Hayford (1932), Russell (1935), Needham (1938) and Davis (1953).

On the other hand, very little work has been done on fecundity of wild speckled trout. Vladykov in 1956, suggests up to that time there were only six other reports in the literature (Titcomb, 1897; Ricker, 1932; Stobie, 1939; Vladykov and Legendre, 1940; Smith, 1947; and Allen, 1956). More recent papers are by Rounsefell (1957), McFadden (1961) and Wydoski and Cooper (1966).

Most data were scanty until Vladykov's (1956) comprehensive paper on the fecundity of Quebec's wild speckled trout. He was the first to deal with the seasonal variation in the number of ova in relation to the egg's diameter. This was shown to be of prime importance in establishing an accurate criterion for fecundity.

Vladykov (1956) points out that in the ovaries of speckled trout, regardless of its age, eggs are always present. Even in small immature trout, eggs of two types can be distinguished, and in larger females usually three types of eggs are observed. Vladykov (1956) defines these three egg types as follows:

Class A: Recruitment Stock. These are small, yolkless, transparent eggs present in clusters between eggs of Class B. The egg diameter is 0.1-0.9 mm. (See Plates VIII: 2 and 3).

Class B: Maturing eggs. Yolk is present, yellowish color or turning orange towards spawning. They gradually decrease in number but increase in size and are thus distinct from the remaining eggs. The egg diameter varies throughout the season from 1.0 to 4.8 mm. (See Plates VIII: 1 and 2).

Class C: Atretic eggs. These are maturing eggs which stop developing. They are irregular in shape, appear pure white in early stages, but become progressively darker as degeneration proceeds. Their diameters are from 1-3 mm.

Vladykov (1956) was the first to point to the value of atresia in trout eggs, suggesting that it acts as a "safety value". Only a small percentage of the recruitment stock of eggs eventually mature and are spawned. If all recruitment stock matured, the ovary weight would be fantastic. The number of atretic eggs varies considerably with the season, locality, and food, of the fish. The number of atretic eggs is highest early in the season when Class B eggs start to mature, and lowest just prior to spawning when most have been absorbed. Under conditions of poor nutrition and growth, all eggs may become atretic and be reabsorbed and, as already discussed, maturity may be postponed for that year. Under exceptionally favourable conditions, such as in hatcheries, as little as 5 per cent may become atretic (Henderson, 1963), the continuing growth of the fish making room for the increased volume of eggs (Vladykov, 1956).

Because of atresia, one must distinguish between the term "fecundity" and the number of eggs contained in a fish at any given moment. Therefore, fecundity for speckled trout is defined as the number of ripe eggs present

in the ovaries just prior to spawning. This definition has been accepted by McFadden (1961) and Wydoski and Cooper (1966). This definition implies that the number of mature eggs present in the ovaries previous to spawning is the smallest in comparison to the number of maturing eggs which the fish had earlier in the season.

1. Methods of Study

Because atresia has been shown to be of such importance in determining egg numbers, fish used for fecundity studies were taken as close to the spawning season as possible. Fish from all areas were taken between mid-August and mid-September. The areas sampled were Peter's River, St. Mary's Bay; Murray's Pond, near St. John's; Bay Bulls Long Pond; Indian River, Notre Dame Bay; Stephen's Pond, near Bay Bulls; and Berry Hill Pond, Burin Bay Arm. In all, 49 mature female trout were used. Although the sample was small, it was felt that the results were fairly indicative of true conditions as a good range of size (14.9 - 44.1 cm.), as well as age (II^+ - VI^+ years) was used. The stages of maturity of these fish ranged from Stage 3 - Stage 5, with the majority at Stage 4.

Ovaries taken in the field or in the laboratory were first placed in 10 per cent formalin

Enumerations were made by direct count where only several hundred eggs were involved. Larger numbers of eggs necessitated use of the volumetric method as used by Raitt (1933). In using the volumetric method, the ovaries were removed from the formalin, the ovary walls were removed, and the ovaries broken in pieces. These pieces were then stored in

Gilson's fluid to separate the eggs from each other and from connective tissue. The eggs were later washed to remove residual tissue. Cleaned eggs and the water containing them were swirled around to ensure an even distribution of eggs throughout the water. Then, using a wide-mouthed pipette, a sample of eggs and water was removed, and the volume of eggs and water noted. The eggs in this sub-sample were then counted. The volume of eggs and water remaining after the sub-sample was removed and carefully recorded. The total number of eggs was then calculated by simple proportion.

In this study, fecundity is taken as the total number of ripe eggs present in both ovaries, or total fecundity.

2. Variation in the Number of Eggs

There exists a pronounced variation in total fecundity of wild populations of speckled trout. Several of these variations will be discussed briefly, and one will be discussed in some detail.

(a) Individual Variations

The cases of variation in fecundity between individuals of the same size are too numerous to be discussed in any detail; it is perhaps sufficient to mention their existence.

(b) Variation with Season

As we have already discussed, the number of developing eggs decreases as the developmental period progresses. Through atresia, the number of eggs is higher at the beginning of the season than later. The decrease in number is related to increased egg diameter, therefore, as Vladykov (1956) suggests, the variation with season is rather the variations with egg diameter.

(c) Variation with Habitat

Trout from different localities often show a distinct variation in the number of eggs. This variation is often related to the productivity of the area, and thus the nutrition and growth of the trout.

(d) Variation with Heredity

In the case of wild speckled trout, this variation is difficult to separate from other variations. In fish cultural regimes, however, selective breeding for higher fecundity illustrates the role of heredity, as yearling hatchery trout may sometimes produce as much as four times as many eggs as in the wild state (Hayford and Embody, 1930; and Hayford, 1932). Vladykov (1956) however, questions whether this is actually heredity as better feeding simply prevents excessive atresia of maturing eggs.

(e) Variation with Size of the Fish

There exists in all piscine species a direct relationship between size of females and the number of eggs produced. In this study, the relationship between egg number and length, whole weight, and age was studied in some detail.

Rate of growth effects the fecundity of speckled trout; larger fish produce greater numbers of eggs (Ricker, 1932; Vladykov and Legendre, 1940; Smith, 1947; Benson, 1953; Allen, 1956; Vladykov, 1956; Rounsefell, 1957; Brasch, et al, 1958; McFadden, 1961; and Wydoski and Cooper, 1966).

Smith (1947), discussing speckled trout, states, "the number of eggs is obviously related to the weight or volume of the fish rather than the length".

(1) Variation with Length

The 49 mature female trout were arranged into 3.0 cm. length classes and the mean number of maturing eggs was calculated for each length class. The data appears in Table VIII: 6. The empirical data were then fitted to a log regression of the form Log F = n log L + log a, which is the logarithmic form of the exponential $F = aL^n$. The calculated egg number for each length class is also given in Table VIII: 6.

Ricker (1932) combining his own data with those of Titcomb (1897), suggests the relation between the number of eggs and fish length is curvilinear for speckled trout. Like Ricker, Smith (1947), Vladykov (1956), Rounsefell (1957), and Wydoski and Cooper (1966) all suggest the relationship between egg number and fish length is curvilinear or exponential of the form $F = aL^n$.

Allen (1956) and McFadden (1961), however, suggest the relationship can be adequately described by a linear regression, at least over intermediate lengths (4 to 10 inches).

In this study, a scatter plot indicated a curvilinear relationship. The plot of logarithm of fork length against the logarithm of mean egg number gives a straight line (Figure VIII: 2a). Smith (1947) and Rounsefell (1957) also report a straight line relationship for this log-log plot. Rounsefell (1957) suggests that the number of eggs increases approximately as the weight of the fish since the logarithm of egg number plotted against the logarithm of fish length approximates a straight line as does the logarithm of fish weight against the logarithm of fish length. Theoretically then, the egg number should be proportional to the cube of the length ($F = aL^3$ approximately).

TABLE VIII: 6. The relationship between the number of mature eggs per fish and fork length for 49 females of Newfoundland speckled trout.

FORK LENGTH (cm.)	NO. MATURE EGGS	CALCULATED NO. MATURE EGGS
15.0	84	146
18.0	348	259
21.0	514	421
24.0	656	640
27.0	---	927
30.0	1973	1291
33.0	1730	1742
45.0	3150	4618

Table VIII: 7 lists the calculated logarithmic relationship for speckled trout from Newfoundland and other North American localities. It is noticed that the regression for this Province shows that the egg number is approximately proportional to the cube of the length (n = 3.1439). The data from Quebec (Vladykov, 1956) and Pennsylvania (Wydoski and Cooper, 1966) also indicate a similar relationship. However, data from other areas which are taken from McFadden (1961), and based on linear relationships, do not show this cube relationship. This is to be expected since the data are based

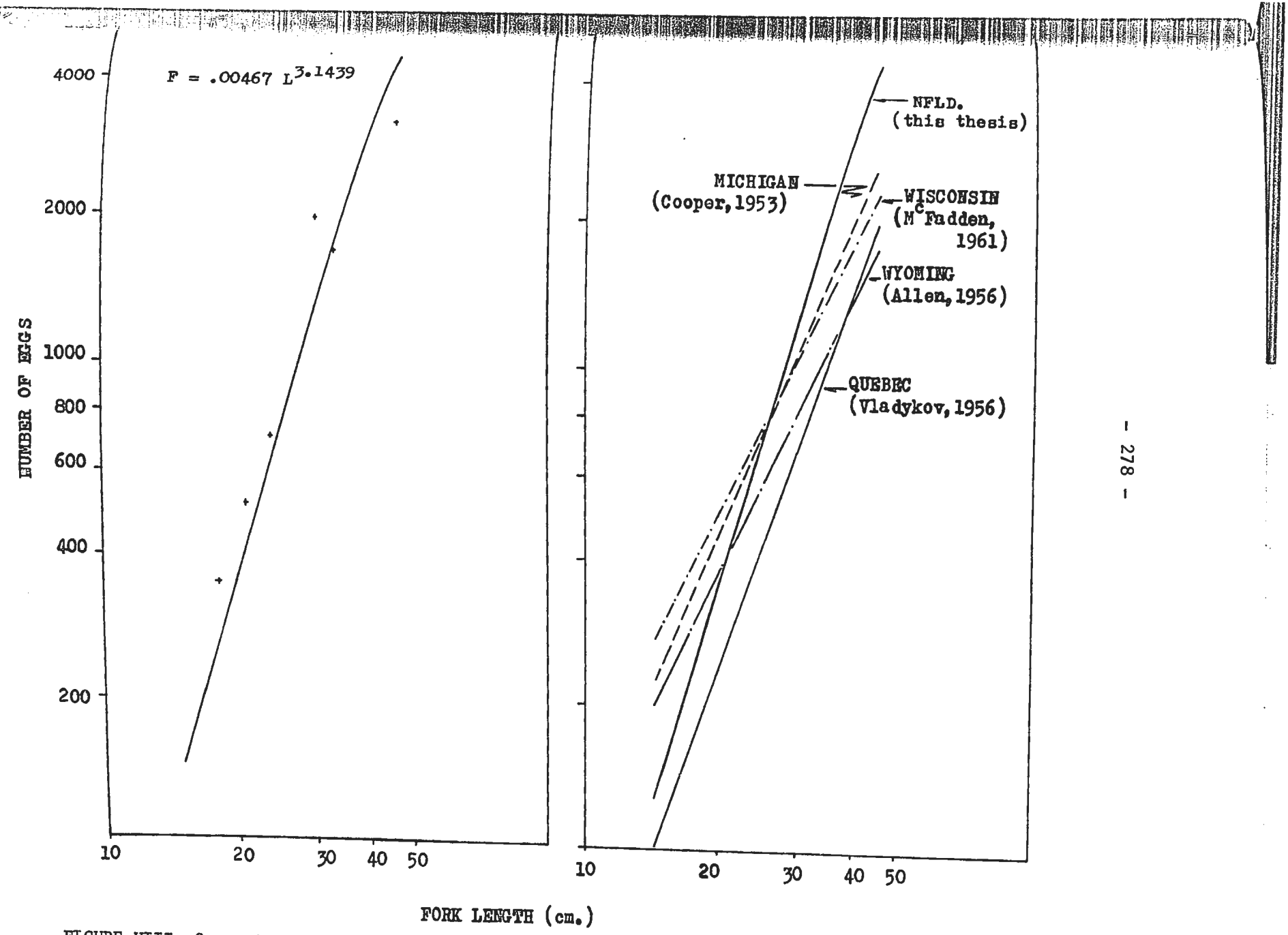


FIGURE VIII: 2a. The relationship between fork length and egg number in Newfoundland speckled trout.

FIGURE VIII: 2b. A comparison of the fecundity of Newfoundland speckled trout and those of other North American localities.

TABLE VIII: 7. Calculated relationships for total number of mature eggs and fork length (cm.) for six North American localities.

LOCALITY	LOG REGRESSION FORM	EXPONENTIAL FORM
Quebec	Log F = 2.6269 Log L - 1.0418	$F = .009082\ L^{2.6269}$
Wyoming	Log F = 1.8357 Log L + 0.1778	$F = 1.506\ L^{1.8357}$
Michigan	Log F = 2.1496 Log L - 0.1392	$F = .07257\ L^{2.1496}$
Wisconsin	Log F = 1.8484 Log L + 0.2989	$F = 1.990\ L^{1.8484}$
Newfoundland	Log F = 3.1439 Log L - 1.5330	$F = .002931\ L^{3.1439}$
Pennsylvania	Log F = 3.2300 Log L - 0.5361	$F = .02910\ L^{3.2300}$

on a small segment of the exponential curve, and the values for the upper range of lengths were extrapolated from supposed linear relationships.

Several authors have reported egg numbers to be approximately proportional to the cube of the length (Mitchell, 1913 and Raitt, 1933; for the haddock; Simpson, 1951; for the North Sea plaice; Bagenal, 1955 and Pitt, 1964; for the American plaice; Negasaki, 1958; for the Pacific herring; Thompson, 1962; for the Pacific cod; and McFadden et al, 1965; for the brown trout.

Table VIII: 8 gives the data from which the logarithmic relationships of Table VIII. 7 were calculated. These data are presented graphically in Figure VIII: 2b and compare the fecundity of Newfoundland trout with those

TABLE VIII: 8. Comparison of fecundity of speckled trout from five different North American localities (modified after McFadden, 1961).

FORK LENGTH (cm.)	Quebec (Vladykov,1956)	Wyoming (Allen,1956)	Michigan (Cooper, 1953)	Wisconsin (McFadden, 1961)	Nfld. (This Thesis)
14.4	100	195	215	268	129
19.0	200	349	430	476	307
21.5	300	432	550	591	453
24.0	400	516	670	707	640
27.0	500	616	830	857	927

of other localities. It is seen that although smaller fish are less fecund, larger Newfoundland speckled trout are somewhat more fecund than their mainland counterparts. It must be kept in mind, however, that direct comparison is difficult since data from Michigan, Wisconsin, and Wyoming are based on small size ranges and linear relationships.

Variation in egg numbers between populations of speckled trout is not unusual. As with sexual maturity, McFadden (1961) suggests "fecundity is a labile property in brook trout".

Vladykov (1956) reports variation in egg number produced by speckled trout from different lakes within the same locality and also presents evidence

of a change in fecundity within a 10-year period, this change being attributed to environmental and population density changes.

McFadden (1961) suggests populations in Wisconsin may vary markedly due to environmental conditions, and he suggests the possibility that the fecundity of these trout could conceivably change in future if some of the environmental factors are altered.

Wydoski and Cooper (1966) report wide variation among Pennsylvania populations.

McFadden et al (1965) suggest productivity of the water is responsible for variation in egg number for brown trout. Svardson (1949) suggests egg number may be strongly influenced by the environment. He also suggests intraspecific variation may correspond to geographical climes.

The influence of genetics on fecundity has not been ruled out. However, Scott (1956) has shown that for rainbow trout, only egg size is genetically controlled while egg number varies with environmental and physiological conditions, and this is probably true of speckled trout.

Generally, it can be said that the egg number of Newfoundland speckled trout is approximately proportional to the cube of the length, or to the weight; and compares favorably with other North American localities.

(2) Variation with Weight

Table VIII: 9 shows the relationship between egg number and whole weight (gm.) for Newfoundland speckled trout. The weights were arranged in 41 gram weight classes and the mean egg number determined for each class. The empirical data were then fitted to a logarithmic regression of the form $\text{Log } F = n \log W + \log a$. The calculated egg number for each weight class is also given in Table VIII: 9. The value of n was found to be 1.0340

TABLE VIII: 9. The relationship between the number of mature eggs per fish and whole weight (gm.) for 49 females of Newfoundland speckled trout.

WHOLE WEIGHT (gm.)	NO. MATURE EGGS	CALCULATED NO. MATURE EGGS
20	61	74
61	218	235
102	545	399
143	396	566
184	717	735
225	1009	905
266	---	1075
307	1760	1247
348	2070	1420
389	1880	1593
430	1920	1767
471	1349	1942
1077	3150	4567

$$\text{Log } F = 1.0340 \log W + 0.5243$$
$$F = 3.344 \; W^{1.0340}$$

indicating that egg number is approximately proportional to the whole weight, as already suggested.

A plot of the logarithm of whole weight against the logarithm of egg number is illustrated in Figure VIII: 3b.

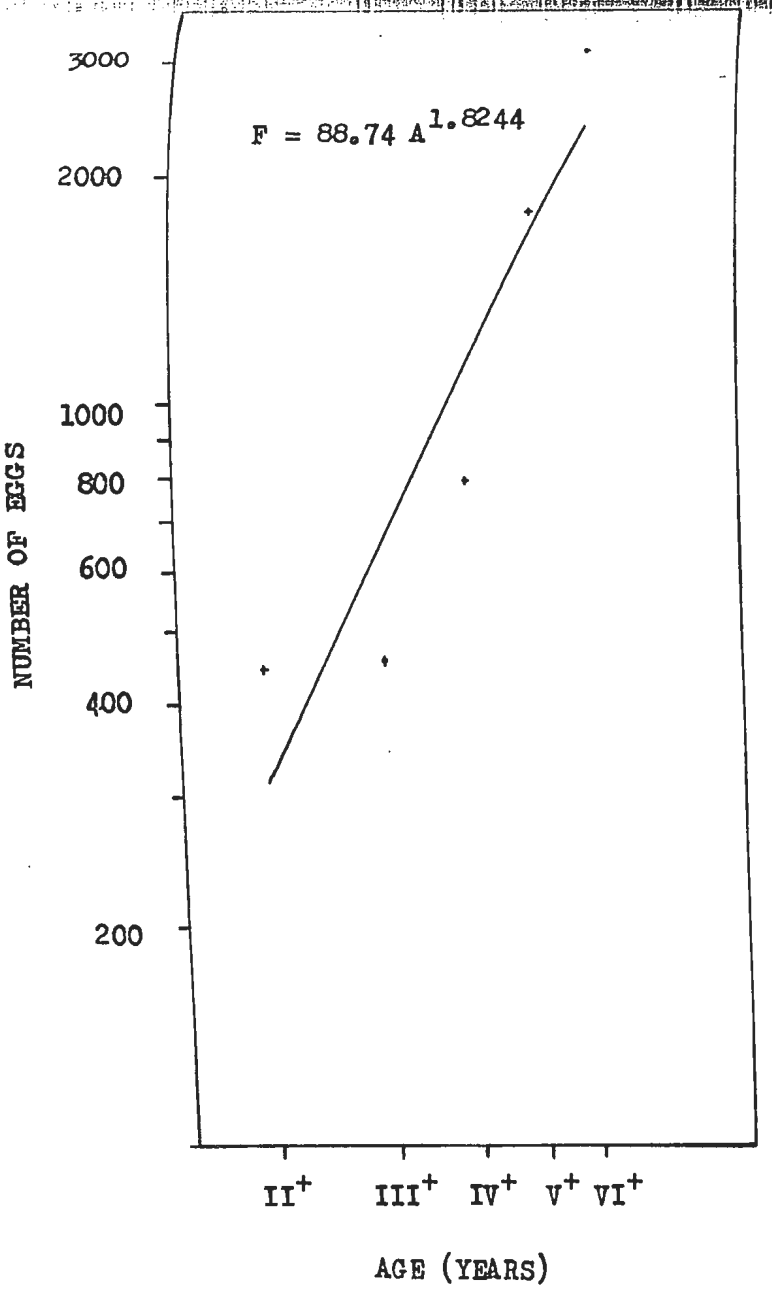


FIGURE VIII: 3a. The relationship between age and egg number in Newfoundland speckled trout.

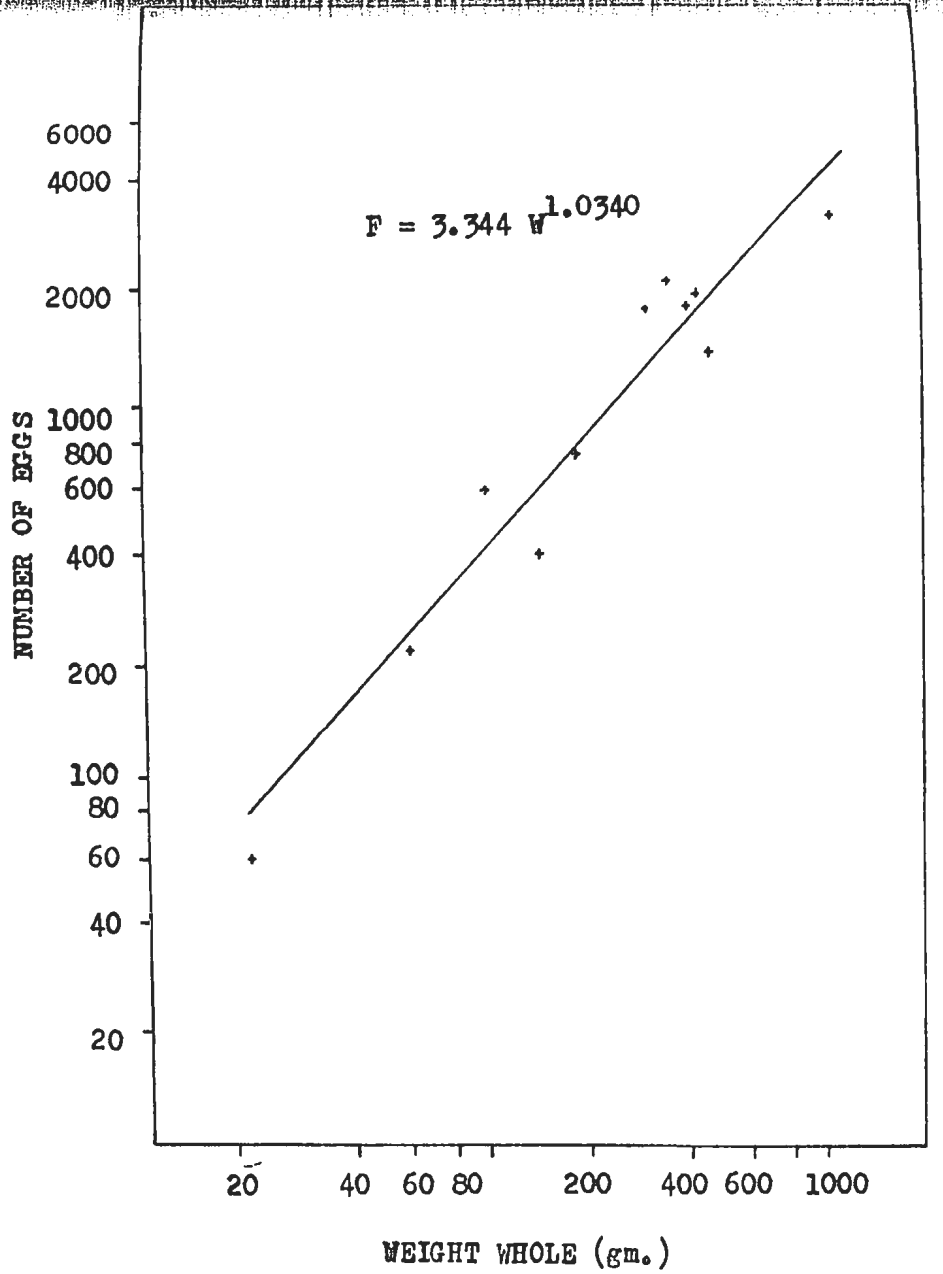


FIGURE VIII: 3b. The relationship between whole weight and egg number in Newfoundland speckled trout.

(3) Variation with Age

It has already been shown that egg production in speckled trout bears a relationship with fish size. Because size is a function of age, there should also be a relationship, however weak, between egg number and age.

Table VIII: 10 shows the mean number of eggs produced by each age group of mature fish. The data were fitted to a log regression of the form $\text{Log } F = n \log A + \log a$, and calculated mean egg numbers are also given. The regression coefficient n assumes a value of 1.8244. This value indicates the egg number is approximately proportional to the square of the age.

The logarithmic plot of age against egg number is shown in Figure VIII: 3a.

It is generally accepted that in fish of the same age, as well as in a collection of fish of different ages, the larger the fish the greater the fecundity. It is reasonable to assume that fecundity is not entirely independent of age (in the larger fish); it is however, the size (or perhaps more specifically, the weight) which plays the significant part and fecundity is very much more related to the size of the fish than to the age.

E. Spawning

No observations were made on the natural spawning of Newfoundland speckled trout and so no discussion is forthcoming on the subject. However, the reader is referred to excellent papers on the subject by Greeley (1932), White (1932, 1934), Schultz (1937), Hazzard (1938), Smith (1941), and Needham (1961).

During the fall of 1966, cursory observations were made on several speckled trout to determine the time of spawning. Four speckled trout were

TABLE VIII: 10. The relationship between the number of mature eggs per fish and age (years) for 49 females of Newfoundland speckled trout.

AGE (Years)	NO. MATURE EGGS	CALCULATED NO. MATURE EGGS
II^+	445	314
III^+	457	659
IV^+	789	1114
V^+	1778	1673
VI^+	3150	2332

$$\text{Log } F = 1.8244 \text{ Log } A + 1.9481$$

$$F = 88.74\ A^{1.8244}$$

collected by seine from Donney's Pond on the Witless Bay Line on the 15th of November. These were two males and two females of fork length 16.5 cm., 17.0 cm., 18.0 cm., and 18.5 cm., respectively. All were III^+ years of age, and all were spent.

Later, on November 24th, four trout were taken by gill netting at Murray's Pond. These were again two males and two females. They were 20.0 cm., 21.0 cm., 22.5 cm., and 25.0 cm., in length respectively. The two males and the smaller female were III^+ years of age and the larger female was

IV^+ years. All fish were spent; the two females were found to contain several empty shells of unspent eggs.

Spawning had not commenced by September 25th, at least in Bay Bulls Long Pond. The author, however, observed many trout lying close to the bottom in a long deep trench. The trout showed little interest in feeding, as it required a couple of hours for the author to angle nine trout for fecundity studies, seven of which were ripe females. The females were all in maturity stage 5, and slight pressure could easily cause ejection of eggs through the genital pore.

Frost (1940) reports that the first fish (speckled trout) arrived on the spawning grounds of Murray's Pond in 1937 on October 12th and the season was at its height during the last week of October, and was not definitely over until the middle of November. She reports that a year later (1938), the season was from October 15th to November 18th.

The caretaker of the Murray's Pond hatchery, Mr. Gerald Murphy (personal communication) informed the author that the peak was reached on October 15th in 1966. From these observations, it would appear that spawning occurs from the first week or so in October to the middle of November.

The main environmental factors inducing spawning in speckled trout are photoperiods and water temperature. These factors undoubtedly are responsible for earlier spawning in more northern climes as suggested by several aurhors (Ricker, 1932; White, 1934; Vladykov, 1956; and Bigelow et al, 1963).

PART IX: FOOD OF SPECKLED TROUT

A. Introduction

Food relationships partly determine population levels, rates of growth, and condition of the fish. They also serve as a partial basis for determination of intraspecific competition. For all piscine species food habits change with season, life history stages, and with the kinds of food available. A distinction should be made between food habits, or food eaten, and feeding habits which are the behavioral aspects of feeding.

It can generally be stated that most fish are omnivorous, especially in early life, when they eat and digest both plant and animal foods. As the fish becomes older, feeding adaptions usually develop and the diet becomes somewhat more restricted. For the salmonids, the change is towards a carnivorous diet, and for most individuals an insectivorous diet in particular. Indeed, Slastenenko (1958) and Vladykov (1957) suggest speckled trout are strictly carnivorous, feeding on aquatic insects and their larvae, terrestrial insects, various other invertebrates (Mollusca, Arthropoda, Annelida, etc.), small fish, Amphibia, Reptilia, and even small Mammalia.

Very little work has been reported from Newfoundland on the food of speckled trout. Frost (1940) provides a popular account of the food of almost 400 speckled trout from various localities on the Avalon Peninsula. She lists the various food organisms encountered and makes a brief seasonal comparison. She also suggests there is little difference in diet from one locality to another, and little food selectivity.

There is a good background of information concerning the food habits of speckled trout in other North American localities (Juday, 1907; Hildebrand and Towers, 1927; Leonard, 1927; Greeley, 1926, 1927; Kendall and Dence, 1927; Needham, 1928; Clemens, 1928; Harkness and Ricker, 1929; Metzelaar, 1929; Ricker 1930; 1932; White, 1930, 1940, 1942; and Allen and Claussen, 1960).

All generally agree that small pelagic and benthic crustaceans, along with all stages of insects, comprise the bulk of the diet. Each population, however, has its own food habits which are related to food preference or relative abundance of food organisms in the environment. For this reason, the food habits of speckled trout were studied in various habitat types and in different geographic areas.

B. Methods of Study

The trout used for analysis of food habits were collected by either seine or gill net and the sample in most cases was supplemented by angling. The reader is referred to Section II - Sampling Methods and Materials, for a complete description of the method of sampling.

At Stephen's Pond, Thomas' Pond, and Angle Pond, all trout collected were analyzed for food habits, while at the other localities time did not permit this, and subsampling had to be used. For both Indian Bay Big Pond and Indian River every second fish was analyzed, and for Berry Hill Pond and Big Bear Cave Pond every two out of three fish were analyzed; in all, 579 stomachs were examined.

The prolonged sampling of Stephen's Pond permitted a study of food habits during the months of June, July, and September.

The stomachs of the fish were removed as soon as possible after capture and the entire stomach from the lower esophagus to the pyloric sphincter was removed and placed in appropriately labeled vials containing 10 per cent formalin. The contents of the stomachs were removed at a later date. The examination of the food organisms was made using a dissecting microscope. The food analysis was undertaken by (1) the occurrence method, (2) the number method, and (3) the weight method.

In the occurrence method each food type is expressed as a percentage calculated by dividing the number of stomachs containing the food type by the total number of stomachs. The number method is based on a count of organisms of the particular type present, with each food type evaluated as a per cent of the total number of all types. The weight method is based on percentage dry weight.

The number method had to be modified in cases where small organisms such as zooplankton and diptera pupae were present in large numbers. The numbers had to be estimated in such cases. This estimation was carried out by placing a glass petri dish containing the organisms over a piece of paper on which had been drawn a number of equal sectors in the manner of a pie diagram. The number of organisms in one or more of the sectors (depending on the number) was then counted after the organisms were evenly spread over the bottom of the dish. This sub-sample was then related to the total count.

Organisms were identified to varying levels of classification; these included: subclass, order, family, and genus. In the majority of cases, only fish were keyed to genus. All organisms were identified by referring to Needham and Needham (1962), Pennak (1953), and Ward and Whipple (1959).

The relative importance of food items is based on the combination of the three methods described.

C. Sources of Error

The use of angled fish for food studies has been critized on the basis that it may be selective for heavier feeding fish (Pentelow, 1932) and that fish captured in this way may regurgitate their food (Phillips, 1929). Dimich and Mote (1934) could detect no difference in the amount or nature of food between fish which were angled and those taken by nets. Frost (1940) suggests any type of capture probably results in regurgitation to some extent.

Generally, all three methods of analysis have some inherent source of error to some extent.

The occurrence method has been said to offer insufficient information on the relative importance of different groups in the diet unless large numbers of stomachs are obtained for a particular period of time (Neill, 1938).

Gerking (1962) suggests head capsules of such organisms as midge pupae often tend to accumulate in the stomach and exaggerate the contribution of those organisms when the number method is used.

Leonard and Leonard (1946) suggest that volumetric or weight data may also be misleading unless used in conjunction with the number and frequency of occurrence method.

Hess and Rainwater (1939) suggest a marked difference in the rate of digestion of soft-bodied and heavily chitinized forms such as the Odonata nymphs. The same authors also show that the rate of digestion is a function

of temperature and this becomes important when seasonal changes in food are considered.

From the above sources of error, it is obvious that each method has some inherent drawback; it was for this reason that the three methods were used to give a reasonable indication of the relative importance of each food type. It can be generally said, then, that those food types that rank high in numbers, occurrence, and weight are important food for trout sampled at that instant in time and for that locality.

D. Feeding Habits of Speckled Trout

It has already been stated that trout may begin life with an omnivorous diet, but soon become carnivorous, and insectivorous in particular, and perhaps switch to a heavily piscivorous diet as they become larger. Metzelaar (1929) suggests rainbow and brown trout turn from an insectivorous to a piscivorous diet when they reach a length of nine inches, but that this change is not so pronounced in speckled trout.

Cannibalism is rare and probably only occurs when other food is scarce (Harkness and Ricker, 1929; Ricker, 1930; Frost, 1940; and Scott and Crossman, 1964).

A disparity often exists between the proportion of food organisms present in a body of water and those found in the stomachs of fish feeding in that water. Allen (1938) states that "percentages which the most important food animals make up of the food are probably very much greater than are their percentages in the fauna at the same time, i.e., the fish are performing definite selection in their food". Neill (1938) and Idyll

(1942) suggest food selection by rainbow trout. Dominy (MS) reports food selection by rainbow trout in Murray's and Butler's Pond near St. John's. Frost (1940) and Scott and Crossman (1964), however, suggest there appears to be no food selection by speckled trout in Newfoundland waters. Allen and Claussen (1960) suggest there is a selection with respect to food size. Brasch et al (1958) suggests speckled trout can be taught to discriminate between foods of different particle size but the process is slow in comparison with other salmonids. They suggest availability usually determines the diet. Needham (1928) suggests little selection except for Trichoptera. Wiseman (1951) and Dineen (1951) suggest there is no food selection by speckled trout.

Needham (1928) suggests speckled trout capture most of their food either upon or just below the surface of the water or when adrift in the current in the case of lotic environments.

Hoar (1940) suggests speckled trout show a depression of feeding both at night and at mid-day with the greatest feeding intensity at evening and early morning. He suggests the combination of light and temperature is responsible.

Frost (1940) suggests that during the warmer months of late July and August, a combination of high water temperature and decreased oxygen content results in a marked decrease in feeding.

Reduced feeding results in weight loss and the loss is more rapid at high temperatures (Pentelow, 1939). Trout can, however, adapt themselves to starvation by lowering their metabolism (Phillips and Brockway, 1954; and Adelman, Bingham, and Maatch, 1955). To lower metabolism, activity must be reduced and this possibly explains why, as Frost (1940) reports,

trout are seen lying inactive on the bottom during hot weather. It is during this situation that anglers refer to the trout as being "logy".

Relatively little work has been done on winter feeding of speckled trout until recent times. Frost (1940) reports trout caught in January, February, and March "often had stomachs literally distended with amphipods". Needham (1930) and Lord (1933) suggest trout feed relatively well in winter but rely entirely on aquatic food.

However, because the rate of digestion is slow at low temperatures (Hess and Rainwater, 1939) the efficiency of conversion of food is low. Leonard (1941) reports that the digestive rate of trout taken from Hunt Creek, Michigan was extremely low in winter. Fish were removed from the creek and held in live-boxes for three hours after which they were killed. Leonard states, "... many of the midge and black fly larvae and one large aquatic annelid were still alive and sufficiently vigorous to crawl from the stomach .... Digestion in these fish must have approached a standstill". Indeed, Hess and Rainwater (1939) report the digestive rate as almost nil in 1.9°C water.

Several authors report a reduction or cessation of feeding with the advent of the spawning season (Needham, 1930), (Lord, 1933; Frost, 1940; and Momot, 1965). Needham (1930) suggests the reduction in food intake is the result of lower temperature. Lord (1933), however, suggests sexual excitement rather than lowered temperature is responsible.

E. Qualitative Analysis of the Food

The food items eaten by speckled trout not only vary with the abundance of these items in the environment but also with the nature of the habitat and the season. The food of speckled trout from the various localities studied is listed in Table IX: 1 - 7.

TABLE IX: 1. The food of Indian River (Stream-resident) speckled trout expressed as percentages of occurrence, composition, and weight (based on 55 trout taken August 16-17, 1966).

	Frequency	% occurr.	Number	%	Wt.(mgs)	% wt.
BENTHIC						
Trichoptera (Larvae)	16	29.1	37	10.9	307.6	9.0
Hydracarina	2	3.6	2	0.6	7.3	0.2
Amphipoda	2	3.6	3	0.9	5.0	0.2
Amnicolidae	16	29.1	84	24.8	326.8	9.5
Sphaeriidae	1	1.8	2	0.6	4.3	0.1
Ceratopogonidae	4	7.3	9	2.7	4.1	0.1
Anisoptera (Nymph)	5	9.1	5	1.5	116.3	3.4
Chironomidae (Pupae)	1	1.8	14	4.1	15.3	0.5
Chironomidae (Larvae)	8	14.6	21	6.2	42.9	1.3
TOTAL	--	--	177	52.2	829.6	24.2
PELAGIC						
Coleoptera (Adult)	23	41.8	56	16.5	928.6	27.1
Gasterosteus aculeatus	2	3.6	3	0.9	112.7	3.3
TOTAL	--	--	59	17.4	1041.4	30.4
TERRESTRIAL						
Diptera (Adult)	17	30.9	31	9.1	31.5	0.9
Trichoptera (Adult)	20	36.4	30	8.9	349.9	10.2
Formicidae	7	12.7	16	4.7	36.2	1.1
Oligochaeta	1	1.8	1	0.3	21.5	0.6
Coleoptera	2	3.6	2	0.6	12.1	0.4
Chrysomelidae	8	14.6	13	3.8	26.5	0.8
Arachnida	3	5.5	3	0.9	18.3	0.5
Lepidoptera	2	3.6	2	0.6	39.2	1.1
Apoidea	2	3.6	3	0.9	79.8	2.3
TOTAL	--	--	101	29.8	615.0	17.9
OTHERS						
Debris	6	10.9	--	--	469.8	13.71
Vegetation	7	12.7	--	--	47.1	1.37
Indistinguishable	8	14.6	--	--	424.9	12.4
Empty	1	1.8	--	--	--	--
TOTAL	--	--	--	--	941.8	27.5
GRAND TOTAL	--	--	337	100.0	3427.8	100.0

TABLE IX: 2. The food of Berry Hill Pond speckled trout expressed as percentages of occurrence, composition, and weight (based on 54 trout taken August 10-12, 1966).

	Frequency	% occurr.	Number	%	Wt.(mgs)	% wt.
BENTHIC						
Trichoptera (Larvae)	9	16.7	19	0.4	154.3	2.1
Corixidae	5	9.3	76	1.7	127.2	1.7
Amnicolidae	26	48.2	356	8.1	744.4	10.2
Hirudinea	8	14.8	12	0.3	65.4	0.9
Sphaeriidae	3	5.6	14	0.3	184.8	2.5
Ephemeroptera (Nymph)	18	33.3	63	1.4	122.0	1.7
Ceratopogonidae	13	24.1	259	5.9	105.2	1.4
Chironomidae (Pupae)	13	24.1	1338	30.3	627.1	8.6
Amphipoda	30	55.6	2198	49.7	1086.4	14.8
TOTAL	--	--	4335	98.0	3216.8	43.9
PELAGIC						
Coleoptera (Adult)	5	9.3	5	0.1	72.2	1.0
Gasterosteus aculeatus	1	1.9	11	0.3	183.9	2.5
Salvelinus fontinalis	1	1.9	1	Trace	131.5	1.8
Salmo salar	1	1.9	1	Trace	3223.7	44.0
Daphnia sp.	2	3.7	∞	--	48.0	0.7
Ostracoda	10	18.5	29	0.7	13.0	0.2
TOTAL	--	--	47	1.1	3672.3	50.1
TERRESTRIAL						
Diptera (Adult)	15	27.8	29	0.7	43.8	0.6
Zygoptera (Adult)	3	5.6	6	0.1	66.1	0.9
Oligochaeta	1	1.9	1	Trace	5.6	0.1
TOTAL	--	--	36	0.8	115.5	1.6
OTHERS						
Debris	1	1.9	--	--	53.7	0.7
Indistinguishable	13	24.1	--	--	267.1	3.7
Empty	1	1.9	---	---	--	--
TOTAL	--	--	--	--	320.8	4.4
GRAND TOTAL	--	--	4422	100.0	7325.4	100.0

TABLE IX: 3. The food of Stephen's Pond speckled trout expressed as percentages of occurrence, composition, and weight (based on 104 trout taken throughout the summer of 1965).

	Frequency	% occurr.	Number	%	Wt.(mgs.)	% wt.
BENTHIC						
Trichoptera (Larvae)	16	15.4	35	1.5	681.2	6.3
Hydracarina	7	6.7	100	4.3	38.8	0.4
Amnicolidae	27	26.0	309	13.3	639.9	5.9
Hirudinea	1	1.0	2	0.1	4.3	Trace
Sphaeriidae	9	8.7	126	5.4	1037.8	9.6
Ephemeroptera (Nymph)	15	14.4	376	16.2	2301.4	21.3
Ceratopogonidae	14	13.5	35	1.5	22.5	0.2
Anisoptera (Nymph)	29	27.9	60	2.6	1874.2	17.4
Zygoptera (Nymph)	7	6.7	104	4.5	20.4	0.2
Diptera (Larvae)	47	45.2	237	10.2	1760.5	16.3
Chironomidae (Pupae)	10	9.6	288	12.4	407.6	3.8
Amphipoda	15	14.4	94	4.1	55.5	0.5
TOTAL	--	--	1766	76.1	8844.1	82.0
PELAGIC						
Coleoptera (Adult)	15	14.4	25	1.1	178.7	1.7
Nematomorpha	3	2.9	7	0.3	63.0	0.6
Gerridae	3	2.9	3	0.1	9.2	0.1
Ostracoda	32	30.8	471	20.3	319.3	3.0
TOTAL	--	--	506	21.8	570.2	5.3
TERRESTRIAL						
Diptera (Adult)	16	15.4	30	1.3	96.7	0.9
Trichoptera (Adult)	7	6.7	17	0.7	392.0	3.6
Oligochaeta	1	1.0	1	0.1	22.2	0.2
TOTAL	--	--	48	2.1	510.9	4.7
OTHERS						
Indistinguishable	14	13.5	--	--	867.5	8.0
Empty	4	3.9	--	---	--	--
TOTAL	--	--	--	--	867.5	8.0
GRAND TOTAL	--	--	2320	100.0	10792.7	100.0

TABLE IX: 4. The food of Angle Pond speckled trout expressed as percentages of occurrence, composition, and weight (based on 109 trout taken in June, 1965).

	Frequency	% occurr.	Number	%	Wt. (mgs)	% wt.
BENTHIC						
Trichoptera (Larvae)	21	19.3	122	3.0	952.1	4.7
Hydracarina	3	2.8	39	0.9	40.4	0.2
Amphipoda	17	15.6	33	0.8	77.8	0.4
Amnicolidae	22	20.2	605	14.7	1550.3	1.6
Planorbidae	1	0.9	5	0.1	18.6	0.1
Hirudinea	1	0.9	1	Trace	15.0	0.1
Ephemeroptera (Nymph)	29	26.6	530	12.9	2407.6	11.9
Ceratopogonidae	10	9.2	14	0.3	8.3	Trace
Sphaeriidae	12	11.0	921	22.3	1954.4	9.6
Anisoptera (Nymph)	16	14.7	31	0.8	1616.9	8.0
Zygoptera (Nymph)	12	11.0	26	0.6	216.5	1.1
Corixidae	2	1.8	2	Trace	1.0	Trace
Chironomidae (Pupae)	32	29.4	1478	35.9	1966.3	9.7
TOTAL	--	--	3807	92.3	10825.2	53.3
PELAGIC						
Coleoptera (Adult)	37	33.9	82	2.0	1022.6	5.1
Gasterosteus aculeatus	28	25.7	59	1.4	5632.5	27.8
Nematomorpha	2	1.8	2	Trace	11.8	0.1
Daphnia sp.	2	1.8	∞	--	124.1	0.6
TOTAL	--	--	143	3.4	6791.0	33.6
TERRESTRIAL						
Diptera (Adult)	8	7.3	44	1.1	155.2	0.8
Tipulidae (Adult)	1	0.9	4	0.1	90.0	0.4
Trichoptera (Adult)	6	5.5	55	1.3	778.3	3.8
Coleoptera (Adult)	11	10.1	27	0.7	116.4	0.6
Isopoda	4	3.7	38	0.9	459.4	2.3
Arachnida	2	1.8	3	0.1	19.3	0.1
Oligochaeta	1	0.9	1	Trace	23.3	0.1
TOTAL	--	--	172	4.1	1641.9	8.1
OTHERS						
Debris	1	0.9	--	--	159.5	0.8
Vegetation	9	8.3	--	--	326.1	1.6
Indistinguishable	8	7.3	--	--	535.8	2.6
Empty	9	8.3	--	--	--	--
TOTAL	--	--	--	--	1021.4	5.0
GRAND TOTAL	--	--	4122	100.0	20279.5	100.0

TABLE IX: 5. The food of Thomas' Pond speckled trout expressed as percentages of occurrence, composition, and weight (based on 105 trout taken in June, 1965).

	Frequency	% occurr.	Number	%	Wt. (mgs)	% wt.
BENTHIC						
Trichoptera (Larvae)	58	55.2	277	6.5	3023.5	17.3
Corixidae	55	52.4	272	6.4	1881.0	10.8
Hydracarina	4	3.8	5	0.1	11.9	0.1
Amphipoda	43	41.0	477	11.2	520.6	3.0
Amnicolidae	6	5.7	67	1.6	151.4	0.9
Hirudinea	19	18.1	59	1.4	883.4	5.1
Sphaeriidae	37	35.2	428	10.1	1287.3	7.4
Ephemeroptera (Nymph)	37	35.2	186	4.4	881.9	5.0
Ceratopogonidae	3	2.9	6	0.1	5.3	Trace
Anisoptera (Nymph)	6	5.7	11	0.3	578.7	3.3
Chironomidae (Pupae)	51	48.6	2096	49.4	2152.4	12.3
Zygoptera (Nymph)	2	1.9	2	0.1	13.6	0.1
TOTAL	--	--	3886	91.5	11391.0	65.2
PELAGIC						
Coleoptera (Adult)	44	41.9	122	2.9	866.5	5.0
Fish (Unident.)	2	1.9	2	0.1	62.5	0.4
Daphnia sp.	1	1.0	220	5.2	21.6	0.1
TOTAL	--	--	344	8.2	950.6	5.5
TERRESTRIAL						
Diptera (Adult)	7	6.7	11	0.3	43.8	0.3
Trichoptera (Adult)	1	1.0	1	Trace	21.8	0.1
Formicidae	1	1.0	3	0.1	7.1	Trace
Oligochaeta	1	1.0	1	Trace	9.5	0.1
TOTAL	--	--	16	0.4	82.2	0.5
OTHERS						
Vegetation	4	3.8	--	--	307.6	1.8
Debris	9	8.6	--	--	2290.1	13.1
Indistinguishable	22	21.0	--	--	2465.5	14.1
Empty	5	4.8	--	--	--	--
TOTAL	--	--	--	--	5063.2	29.0
GRAND TOTAL	--	--	4246	100.0	17487.0	100.0

TABLE IX: 6. The food of Big Bear Cave Pond speckled trout expressed as percentages of occurrence, composition, and weight (based on 80 trout taken August 13-16, 1965).

	Frequency	% occurr.	Number	%	Wt.(mgs)	% wt.
BENTHIC						
Trichoptera (Larvae)	9	11.3	34	26.4	349.6	6.5
Amphipoda	1	1.3	2	1.6	8.1	0.1
Anisoptera (Nymph)	1	1.3	1	0.8	15.2	0.3
Chironomidae (Pupae)	4	5.0	8	6.2	12.8	0.2
Amnicolidae	1	1.3	5	3.9	1.0	Trace
Ephemeroptera (Nymph)	1	1.3	1	0.8	5.9	0.1
TOTAL	--	--	51	39.6	392.6	7.2
PELAGIC						
Coleoptera (Adult)	1	1.3	2	1.6	16.0	0.3
Gasterosteus aculeatus	15	18.8	39	30.2	1080.5	20.0
Osmerus mordax	2	2.5	3	2.3	3586.6	66.3
TOTAL	--	--	44	34.1	4683.1	86.6
TERRESTRIAL						
Diptera (Adult)	9	11.3	25	19.4	60.7	1.1
Limax sp.	1	1.3	1	0.8	123.4	2.3
Tipulidae (Adult)	1	1.3	1	0.8	42.7	0.8
TOTAL	--	--	27	21.0	226.8	4.2
OTHERS						
Vegetation	1	1.3	2	1.6	74.4	1.4
Indistinguishable	5	6.3	5	3.9	32.9	0.6
Empty	40	50.0	--	--	--	--
TOTAL	--	--	7	5.5	107.3	2.0
GRAND TOTAL	--	--	122	100.0	5409.8	100.0

TABLE IX: 7. The food of Indian Bay Big Pond speckled trout expressed as percentages of occurrence, composition, and weight (based on 52 trout taken June 24-25, 1966).

	Frequency	% occurr.	Number	%	Wt.(mgs)	% wt.
BENTHIC						
Trichoptera (Larvae)	17	32.7	52	2.4	735.2	5.6
Hydracarina	3	5.8	57	2.6	25.2	0.2
Amphipoda	2	3.8	5	0.2	10.4	0.1
Amnicolidae	1	1.9	1	0.1	2.1	Trace
Hirudinea	4	7.7	5	0.2	61.1	0.5
Ephemeroptera (Nymph)	16	30.8	47	2.1	167.1	1.3
Ceratopogonidae	2	3.8	5	0.2	4.2	Trace
Chironomidae (Pupae)	13	25.0	1988	89.9	959.8	7.3
TOTAL	--	--	2160	97.7	1965.1	14.81
PELAGIC						
Coleoptera (Adult)	7	13.5	10	0.5	66.7	0.5
Gasterosteus aculeatus	7	13.5	8	0.4	400.3	3.0
Osmerus mordax	6	11.5	8	0.4	10226.7	77.3
Daphnia sp.	1	1.9	∞	--	40.4	0.3
Nematomorpha	1	1.9	1	0.1	15.1	0.1
TOTAL	--	--	27	1.4	10749.2	81.23
TERRESTRIAL						
Coleoptera (Adult)	3	5.8	5	0.2	31.0	0.2
Trichoptera (Adult)	1	1.9	2	0.1	13.1	0.1
Diptera (Adult)	2	3.8	7	0.3	14.8	0.1
TOTAL	--	--	14	0.6	58.9	0.4
OTHERS						
Debris	5	9.6	10	0.5	282.3	2.1
Indistinguishable	8	15.4	--	--	173.9	1.3
Empty	6	11.5	--	--	--	--
TOTAL	--	--	10	0.5	456.2	3.4
GRAND TOTAL	--	--	2211	100.0	13229.4	100.0

Vladykov (1957) and Slastenenko (1958) have indicated that speckled trout are strictly carnivorous, while other workers (Metzelaar, 1929; Harkness and Ricker, 1929; and Ricker, 1930, 1932) have reported findings of plants and plant remains in the stomachs, along with some debris.

Vegetation was found in the stomachs of trout from Indian River, Angle Pond, Thomas' Pond, and Big Bear Cave Pond. Debris, which is composed of dead twigs, stones, fish hooks, etc., is considered to have no food value and was encountered in trout stomachs from Indian River, Berry Hill Pond, Angle Pond, Thomas' Pond, and Indian Bay Big Pond. It is of interest to note the presence of fish hooks in the stomachs of two trout. A 14.0 cm. trout from Indian River was found to contain a treble-hook lodged in its stomach, with no sign of corrosion; and a 24.0 cm. trout taken at Angle Pond was found to contain a partly corroded snelled-hook lying in the curvature of its stomach. In both cases, no ill-effect was apparent as the stomachs were distended with food. Ricker (1932) reports finding five fish hooks during an examination of about 1300 stomachs, and Hurst (1931) reports a similar case for brown trout.

The vegetation for the most part was composed of filamentous green algae and seeds. Ricker (1932) and Metzelaar (1929) report similar findings.

The debris was composed mainly of twigs, pieces of bark, stones, and conifer needles.

Metzelaar (1929) and Ricker (1932) suggest this debris is derived from caddis fly larval cases and is not necessarily the result of inefficient feeding. The plant material may have been taken incidentally.

Fish remains were fairly common with the threespine stickleback, Gasterosteus aculeatus; the landlocked Atlantic salmon, Salmo salar; the landlocked American smelt, Osmerus mordax; the speckled trout, and unidentified fish remains present. The stickleback was present in stomachs from Indian River, Berry Hill Pond, Angle Pond, Big Bear Cave Pond, and Indian Bay Big Pond. A landlocked salmon was found in the stomach of a Berry Hill Pond trout, as was one speckled trout, the only case of cannibalism encountered. The two Indian Bay Ponds yielded trout stomachs containing landlocked smelt. Unidentified fish remains were found in a Thomas' Pond trout. The presence of fish in the diet of speckled trout is not uncommon (Clemens, 1924; Metzelaar, 1929; Needham, 1930; Ricker, 1930, 1932; Frost, 1940; and White, 1940, 1942); however, Leonard (1941) and Card (1933) report no fish remains.

The case of cannibalism is not common but has been reported by other authors (Ricker, 1930; Frost, 1940; and Scott and Crossman, 1964). Leonard (1938) reports, however, that a Michigan creek carrying a heavy population of naturally hatched fry showed no evidence of cannibalism when the stomachs of 14 adults were examined. The presence of sculpins, however, indicates the fish are piscivorous.

1. Benthic Fauna

Trichoptera larvae, Amphipoda, and Amnicolidae appeared in stomachs from all localities and were dominant food organisms. Other important food items were Sphaeriidae, Anisoptera nymphs, Ceratopogonidae, Zygoptera nymphs, Hirudinea, Ephemeroptera nymphs, and Chironomid pupae. Lesser food elements were Hydracarina, Chironomid larvae, Corixidae, and Planorbidae.

2. Pelagic Fauna

Adult aquatic Coleoptera were found in stomachs from all localities

and are a very dominant food item. Fish are also an important food item; of lesser importance are Ostracoda, Nematomorpha, Gerridae, and Daphnia sp.

3. Terrestrial Fauna

The most common terrestrial food were adult Trichoptera, and aerial Diptera. Also of some importance were Isopoda, Formicidae, Oligochaeta, Coleoptera, and Arachnida. Lesser numbers of Chrysomelidae, Lepidoptera, Apoidea, Tipulidae, and Limax sp. were also encountered.

4. Miscellaneous

Under miscellaneous are included such items as vegetation, debris, indistinguishable material of food value, and unidentifiable matter.

F. Quantitative Analysis of the Food

As already stated, the relative importance of the food items is based on the combination of the three methods of analysis; (1) occurrence, (2) number, and (3) weight.

Therefore, the results obtained using the three methods are combined and the composite results indicate to a fair degree of accuracy, the relative importance of various food organisms utilized in the various localities.

1. Indian River

The dominant food organisms are adult aquatic beetles (Coleoptera), adult and larval caddis fly (Trichoptera), aquatic snails (Amnicolidae), true adult flies (Diptera), and dragonfly nymphs (Anisoptera).

2. Berry Hill Pond

The dominant food organisms for trout of this pond are water scuds

(Amphipoda), aquatic snails (Amnicolidae), midge pupae (Chironomidae), mayfly nymphs (Ephemeroptera), caddisfly larvae (Trichoptera), true adult flies (Diptera), water boatmen (Corixidae), and leeches (Hirudinea).

3. Stephen's Pond

The food of trout in this pond is composed mainly of mayfly nymphs (Ephemeroptera), damselfly nymphs (Zygoptera), aquatic snails (Amnicolidae), dragonfly nymphs (Anisoptera), adult and larval caddisfly (Trichoptera), water scuds (Amphipoda), ostracods (Ostracoda), true adult flies (Diptera), midge pupae (Chironomidae), fingernail clams (Sphaeriidae), and adult aquatic beetles (Coleoptera).

4. Angle Pond

The main food items utilized by trout in this area are midge pupae (Chironomidae), mayfly nymphs (Ephemeroptera), aquatic snails (Amnicolidae), stickleback (Gasterosteus aculeatus), adult and larval caddisfly (Trichoptera), fingernail clams (Sphaeriidae), adult terrestrial and aquatic beetles (Coleoptera), dragonfly nymphs (Anisoptera), and damselfly nymphs (Zygoptera).

5. Thomas' Pond

The major food organisms encountered were midge pupae (Chironomidae), adult and larval caddisfly (Trichoptera), water boatmen (Corixidae), fingernail clams (Sphaeriidae), mayfly nymphs (Ephemeroptera, water scuds (Amphipoda), adult aquatic beetles (Coleoptera), and leeches (Hirudinea).

6. Big Bear Cave Pond

The major food items here were the stickleback (Gasterosteus aculeatus), caddisfly larvae (Trichoptera), landlocked smelt (Osmerus mordax), true adult flies (Diptera), midge pupae (Chironomidae) and aquatic snails (Amnicolidae).

7. Indian Bay Big Pond

The food organisms most utilized were midge pupae (Chironomidae), landlocked smelt (Osmerus mordax), threespine stickleback (Gasterosteus aculeatus), adult and larval caddisfly (Trichoptera), mayfly nymphs (Ephemeroptera), and terrestrial and aquatic beetles (Coleoptera).

An examination of Tables VIII: 1-7 along with the foregoing discussion, indicates that the constituents of the speckled trouts' diet are similar in most areas studied, even though their relative importance in the diet may vary from one locality to another. Generally, the food of speckled trout as reported by Frost (1940) is in complete agreement with data obtained in this study.

Table IX: 8 shows the relative amount of food taken from the stomachs of trout from different localities. It is seen that the total weight of food per gram of fish increases with increased habitat size up to a maximum and then decreases. This is undoubtedly related to the higher productivity of small and medium sized ponds and the lower productivity of streams and lakes. It is of particular interest that the two large Indian Bay Ponds have the lowest relative amounts of food per gram of fish. Recall that the three areas showing the lowest relative food amounts (Indian River, Big Bear Cave Pond, and Indian Bay Big Pond) have the lowest values of condition. Neill (1938), Benson (1954), Ellis and Gowing (1957), and Allen (1940) report the same relationship.

Recall, however, that the two Indian Bay Ponds have good growth rates. This, therefore, implies that the quality of food rather than quantity is of prime importance. McCay and Dilley (1947) and McCay, Bing, and Dilley (1928)

point out that trout need "fresh meat" or some substance contained in it in order to grow properly. They called this Factor H. Burrows and Karrick (1947) and Cooke and Tomlinson (1950) show the value of salmon viscera. Larkin, Terpenning and Parker (1956) show the value of a forage fish for trout and Idyll (1942) suggests coarse fishes like sticklebacks are most important in lakes. Fish are present in the diet of trout from most localities but, in most cases, their contribution is incidental. Fish, however, are prominent in the diet of Angle Pond trout and are of prime importance in the two Indian Bay Ponds, where the stickleback and smelt are staple foods.

Table IX: 8 also indicates the relative importance of benthic, pelagic, and terrestrial foods.

Generally, benthic organisms are utilized relatively more than pelagic organisms. There are, however, three exceptions. At Indian River the influence of pelagic aquatic beetles (Coleoptera) alone is greater than that of all benthic organisms combined. At Berry Hill Pond, the higher relative amount of pelagic food is due almost entirely to three fish in the diet, a speckled trout, a landlocked salmon and a stickleback. At Big Bear Cave Pond the presence of fish in the diet is also responsible for a higher relative amount of pelagic food; however, in this instance fish are one of the staples in the diet.

In all cases, terrestrial food is relatively less important than either benthic or pelagic. There is a general decrease in the amount of terrestrial food with increase in habitat size. At Indian River, however, foods of terrestrial origin are utilized to a fair extent and this agrees

TABLE IX: 8. Comparison of the relative amount of food of speckled trout from the various localities expressed as mg. of food per gram of fish.

LOCALITY	Mg. of food per gram of fish			
	Benthic	Pelagic	Terrestrial	Total
Indian River	0.2300	0.2885	0.1705	0.9505
Berry Hill Pond	0.6287	0.7177	0.0225	1.4318
Stephen's Pond	0.9840	0.0634	0.0568	1.2008
Angle Pond	0.7601	0.4768	0.1152	1.4240
Thomas' Pond	0.9342	0.0779	0.0067	1.4342
Big Bear Cave Pond	0.0248	0.2962	0.0067	1.3422
Indian Bay Big Pond	1.0850	0.5937	0.0033	0.7307

with the reports of several authors (Clemens, 1928; Ricker, 1930; Muttkowski, 1925; Hoover, 1939; Ellis and Gowing, 1957; Tebo and Hassler, 1963; and Reed and Bear, 1966).

The stomachs of 20 sea-run speckled trout taken at Indian River during August 1966 were examined but no trace of food was found. The stomachs were in a contracted condition and indicated the fish had not been feeding for some time. Similar findings are reported by White (1940, 1942) for Moser River sea trout. It is also of interest that the condition of these trout is very low, in fact, lower than stream-resident trout. This is also reported by Wilder (1952) who suggests condition is poorer in August and September for sea trout, and White (1942) suggests they lose weight upon

their return to fresh water. Scott and Crossman (1964) suggest the stoppage in feeding is perhaps due to physiological readjustment to fresh water and the sudden absence of the larger food organisms which they had been utilizing in the sea. They suggest the fact that they will rise for artificial flies indicates some ability and willingness to take food.

White (1942) suggests their marine diet is mainly of a piscivorous nature, feeding on such fish as squirrel hake, eel elvers, sea raven, mummichog, rock gunnel, smelt, and silversides. Other food items include marine isopods, amphipods, shrimp, and sand worms.

G. Variation in Food with Size of Speckled Trout

Several authors have commented on the change in diet of the speckled trout with increased size (Clemens, 1928; Metzelaar, 1929; Harkness and Ricker, 1929; White, 1930; Ricker, 1930, 1932; Allen, 1960; and Momot, 1965).

Clemens (1928) suggests trout of 0-2 inches feed mainly on midge larvae; trout 2-4 inches in length feed mainly on mayflies; 4-6 inch trout were found to contain mainly grasshoppers; trout of 6-8 inches feed mainly on fish, and fish and amphibians formed the bulk of the diet of 8-10 inch trout.

Metzelaar (1929) suggests there is an "unmistakable decrease of insects in the diet and an equally sharp increase in crustacea (crayfish) and fish as the size of the trout increases."

White (1930) examined speckled trout fry for stomach contents soon after they emerged from the redds, and in many cases the yolk sac had not been absorbed. He found the bulk of the food was composed of chironomid larvae and copepods.

Ricker (1930) also suggests that entomostraca (Ostracoda, Copepoda, and Cladocera) compose the bulk of the food of fry. He suggests that at a length of one inch or so they turn to an insect diet with chironomid larvae making up the bulk. Between 1.5 and 3 inches the number of chironomid larvae falls off and more stream and terrestrial insects are utilized. From 3-4 inches, Ricker suggests a further reduction in chironomids and an increase in insect fauna. Stomachs of 4-6 inch trout show the first appearance of crayfish, and at 6-8 inches fish assume a dominant position in the diet. Then from 10-20 inches the diet is almost entirely crayfish and fish.

Momot (1965) suggests trout populations can be divided into two ecological categories, and suggests the approximate point of division is at a mean length of 8 inches. He suggests speckled trout of eight inches or over eat mainly crayfish, most insects are eaten by medium-sized trout, and most of the daphnia consumed is by small trout.

Allen and Claussen (1960) suggests that in the absence of such large organisms as fish and crayfish, large trout may select the larger of existing food organisms, and they show that larger trout eat larger Coleoptera than do small trout.

Table IX: 9 shows a comparison of the food eaten by speckled trout of various sizes in Angle Pond. The occurrence method was used to illustrate differences as it was felt that the number and weight methods would be more directly a function of size. The most noteworthy point is the increase in the occurrence of the stickleback in the diet of larger trout. None were taken by trout 10-15 cm. in length but they formed the bulk of the diet of 25-30 cm. fish. It is also of interest to note that the frequency of occurrence of other food items shows no consistent trends with increased size of the trout,

TABLE IX: 9. A comparison of the food eaten by speckled trout of various sizes in Angle Pond.

FOOD ORGANISM	FREQUENCY AND PERCENTAGE FREQUENCY OCCURRENCE OF ORGANISMS							
	Size Group (cm.)							
	10.55-15.55 (10)		15.55-20.55 (33)		20.55-25.55 (58)		25.55-30.55 (8)	
Trichoptera (Larvae)	(2)	20.0	(7)	20.6	(12)	20.7	--	--
Hydracarina	—	—	—	—	(2)	3.4	(1)	12.5
Amphipoda	—	—	(6)	17.6	(9)	15.5	(2)	25.0
Ammicolidae	(2)	20.0	(8)	24.2	(11)	19.0	(1)	12.5
Hirudinea	--	—	(1)	2.9	—	—	—	—
Ephemeroptera(Nymph)	(2)	20.0	(9)	26.5	(16)	27.6	(2)	25.0
Ceratopogonidae	(2)	20.0	(3)	8.8	(5)	8.6	--	—
Sphaeriidae	(1)	10.0	(7)	20.6	(4)	6.9	—	—
Anisoptera (Nymph)	(2)	20.0	(5)	15.2	(8)	13.8	(1)	12.5
Zygoptera (Nymph)	(1)	10.0	(2)	5.9	(7)	12.1	(2)	25.0
Corixidae	—	—	(2)	5.9	—	—	—	—
Planorbidae	—	—	(1)	2.9	—	—	—	—
Chironomidae(Pupae)	(1)	10.0	(9)	26.5	(19)	32.8	(1)	12.5
Coleoptera (Adult)	(7)	70.0	(12)	35.3	(15)	25.9	(3)	37.5
Gasterosteus aculeatus	—	—	(4)	11.8	(19)	32.8	(5)	62.5
Nematomorpha	--	—	--	--	(1)	1.7	(1)	12.5
Daphnia sp.	—	--	---	—	(2)	3.4	—	—
Diptera (Adult)	—	—	(3)	8.8	(4)	6.9	(1)	12.5
Tipulidae (Adult)	—	--	--	--	(1)	1.7	--	—
Trichoptera (Adult)	(1)	10.0	(3)	8.8	(2)	3.4	—	—
Terr. coleoptera	(2)	20.0	(2)	5.9	(7)	12.1	--	—
Isopoda	(1)	10.0	(2)	5.9	(1)	1.7	--	--
Arachnida	(1)	10.0	(1)	2.9	—	—	—	--
Oligochaeta	(1)	10.0	--	--	—	—	—	—

with the possible exception of aerial and terrestrial insects which show somewhat of a decline in frequency in larger trout. It is probably, as Allen and Claussen (1960) suggests, that the scarcity of large items such as fish and crustaceans result in the larger fish simply eating the larger of existing organisms.

H. Seasonal Variation in the Food of Speckled Trout

Although numerous authors have reported on the natural food of speckled trout, relatively few have studied the seasonal changes in food habits. Several of the authors who have studied this aspect are Needham (1930), Lord (1933), Leonard (1941), Benson (1953), and Momot (1965).

Needham (1930) lists the foods of speckled trout in New York streams during every month of the year. He suggests terrestrial foods exceed aquatic species in numbers during late summer and early autumn, but are quite scarce during the winter months.

Lord (1933) reports similar results for a Vermont stream; however, he suggests aquatic foods dominate every month except June, August, September, October, and November. He reports that aquatic organisms supply 66.54 per cent of the total food taken during the twelve months, while terrestrial organisms make up the balance.

Momot (1965) suggests that in a Michigan lake insects were the most important items in the diet from April to July, with a peak in importance in May and June. Daphnia became an important component from August to October. He reports crayfish are important during winter months and he suggests trout predation accounts for 60 per cent of the overwinter mortality of young-of-the-year crayfish.

The only information on seasonal trends in food in Newfoundland waters is given by Frost (1940). She reports briefly that, "By the middle of June, flies and dragonflies appear to become an important factor, and at such seasons as the rain or floods wash them into the water, wood lice, ants, and other small land arthropods are eaten greedily". She also suggests amphipods are especially important during January, February, and March.

Table IX: 10 compares the food of speckled trout during the months of June, July, and September for Stephen's Pond.

It is noted that overall both the number and weight of food per stomach shows a steady decrease from June to September. It is also noted that while the amount of benthic organisms per stomach decrease, the amount of pelagic and terrestrial organisms shows an increase over the same period.

The increase of pelagic organisms is due to an increase in the amount of Ostracoda consumed, while the other main pelagic item, adult Coleoptera, remains fairly constant.

The increase in terrestrial organisms is due mainly to an increase in adult Trichoptera which are utilized only in September (no data available for August). Aerial Diptera also show an increase from July to September, and are not present in June.

The reduction in benthic organisms consumed results mainly from a reduction of Ephemeroptera nymphs which are taken only in June. Ceratopogonidae, Anisoptera nymphs, and Chironomidae pupae show a reduction from June to July and are not found in September. The only benthic organisms showing monthly increases in abundance in the stomachs are Trichoptera larvae, Amnicolidae, Zygoptera larvae, and Chironomidae larvae; however, Zygoptera nymphs are not found in September.

TABLE IX: 10. Average number and dry weight of organisms per trout stomach by month in Stephen's Pond, Summer, 1965.

FOOD ORGANISMS	June (24)		July (48)		Sept. (32)		Averages	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
BENTHIC								
Trichoptera (Larvae)	—	—	0.2	4.6	0.9	14.3	0.3	6.6
Hydracarina	—	—	2.0	0.7	0.1	0.1	1.0	0.4
Amnicolidae	2.1	3.2	2.7	4.1	4.1	12.1	3.0	6.2
Hirudinea	—	—	Trace	0.1	—	—	Trace	Trace
Sphaeriidae	0.1	0.9	2.2	17.2	0.6	6.0	1.2	10.0
Ephemeroptera (Nymph)	15.7	95.9	—	—	—	—	3.6	22.1
Ceratopogonidae	0.6	0.4	0.5	0.3	—	—	0.3	0.2
Zygoptera (Nymph)	0.5	2.7	4.7	35.4	—	—	0.6	18.0
Chironomidae (Larvae)	—	—	1.0	0.3	1.8	0.2	1.0	0.2
Chironomidae (Pupae)	6.7	8.6	2.7	4.1	—	—	2.8	3.9
Anisoptera (Nymph)	2.0	51.3	0.3	8.1	—	—	2.3	16.9
Amphipoda	—	—	1.4	0.8	0.8	0.5	0.9	0.5
TOTAL AVERAGES	27.6	162.9	17.5	75.7	8.3	33.2	16.9	85.0
PELAGIC								
Coleoptera (Adult)	0.6	3.3	0.2	1.3	0.1	1.2	0.2	1.7
Nematomorpha	—	—	0.2	1.3	—	—	0.1	0.6
Gerridae	Trace	Trace	—	—	0.1	0.3	Trace	0.1
Ostracoda	1.8	0.9	4.1	2.9	7.3	5.0	4.5	3.1
TOTAL AVERAGES	2.4	4.2	4.5	5.5	7.5	6.5	4.8	5.5
TERRESTRIAL								
Diptera (Adult)	—	—	0.3	0.9	0.5	1.8	0.3	0.9
Trichoptera (Adult)	—	—	—	—	0.5	12.3	0.2	3.8
Oligochaeta	—	—	—	—	Trace	0.7	Trace	0.2
TOTAL AVERAGES	—	—	0.3	0.9	1.0	14.8	0.5	4.9
OTHERS								
Indistinguishable	0.1	1.1	0.2	15.3	Trace	3.3	1.4	8.4
Empty	—	—	Trace	—	0.1	—	—	—
TOTAL AVERAGES	0.1	1.1	0.2	15.3	0.1	3.3	1.4	8.4
GRAND TOTAL AVERAGES	30.0	168.3	22.5	97.3	16.8	57.6	23.6	103.9

Besides the pelagic and terrestrial organisms already mentioned, the only benthic organisms utilized in September are Trichoptera larvae, Hydracarina, Amnicolidae, Sphaeriidae, Chironomidae larvae, and Amphipoda.

The grand averages show that over the summer months benthic organisms comprise 82.0 per cent by weight, pelagic, 5.3 per cent, and terrestrial, 4.7 per cent. 8.0 per cent is composed of miscellaneous material.

Benson (1953) reports that speckled trout in the Pigeon River, Michigan, show an increase in stomach contents during May and June but a decrease from then to September.

Ellis and Gowing (1957) show a decreased number of organisms per brown trout stomach during July and August in a Michigan stream, and suggest it is due to a shift to surface feeding because of a paucity of benthic fauna.

Fewer organisms per stomach during late summer and autumn has also been observed for brown trout by Neill (1938) and Frost (1939), and for salmon smolt (Allen, 1940).

PART X: PARASITES OF SPECKLED TROUT

In this study the only parasites the author was concerned with were the macroscopic variety. These are undoubtedly the most commonly encountered by both the fisheries biologist and sportsman. It was felt that if parasitism had any ill-effect on trout populations, a good share would be due to these macroscopic forms.

The external body surface, fins, and branchial cavity were examined for external parasites, while the digestive tract, body cavity, and visceral surfaces were examined for internal parasites. Organs such as the liver, kidneys, heart, etc., were not dissected for examination and only a cursory examination of the surfaces of these organs was made.

Contrary to popular opinion, parasitism is very common. Meyer (1964) suggests there are indications that there may be more organisms living as parasites than there are free-living. Under natural conditions there is rarely a single fish, among all the numerous species, which does not act as host for at least one or more species of parasites. Linton (1893) suggests, "of all animals . . . the class of fishes takes the lead, not only for the variety of forms and the number of individuals harbored, but also for the frequency of individual cases of parasitism". Parnell (1934) suggests over 80 per cent of freshwater fishes are parasitized.

Under natural conditions most of the parasites produced are lost to enemies or to the expanse of water before they can infect fish. Richardson

(1936) for example, suggests it is seldom that parasitic infection of speckled trout living under natural conditions assumes a serious proportion as to endanger sport fishing. Under crowded conditions or inadequate water and oxygen supply, trout may become seriously infested and in such cases more damage is done. Such a case is reported by Richardson (1936) for Lake Edward, Quebec, where the parasitism is suggested as the reason for poor fishing.

Much of the damage from parasites is mechanical. Tissues are injured, and blood vessels are often blocked by burrowing. Some parasites actually ingest flesh, mucus or body fluids, while still others release toxic materials in the host. Fish thus weakened are easy prey for predators, and this is perhaps one of the more serious results of parasitism.

Frost (1940) was the first to report on the nature of speckled trout parasites from Newfoundland waters. During her cursory examination she encountered two external and three internal parasites, all of the macroscopic variety. The two external parasites were (1) parasitic copepods, which she identified as Salmincola edwardsii, and (2) encysted flukes of the family Heterophyidae. The internal parasites were (1) spiny-headed worms or Acanthocephalae, (2) flukes of the families Gorgoderidae and Alloereadiidae, and (3) tapeworms of the genus Abothrium.

Pippy (MS), in a comprehensive study of the parasites of Newfoundland freshwater fishes, lists seventeen parasites of speckled trout (Table X: 1).

Of these only Eubothrium salvelini, Echinorhynchus lateralis, and Phyllodistomum sp. are generally distributed. Apophallus sp. is generally distributed with the exception of the Great Northern Peninsula. Discocotyle salmonis was found to be most abundant on the Burin Peninsula, but was also

TABLE X: 1. Parasites of Newfoundland speckled trout (from Pippy MS, 1965).

PARASITE	SITE OF INFESTATION
Trichophyra piscium Butschli, 1889	Gills
Ichthyophthirius sp.	External surface
Discocotyle salmonis Shaffer, 1916	Gills
Crepiodostomum farionis (Muller, 1784) Luke, 1904.	Intestine and gall bladder
Azygia longa (Leidy, 1851)	Stomach
Bunodera luciopercae (Muller, 1776) Luke, 1907	Intestine
Phyllodistomum sp.	Ureters and bladder
Apophallus sp.	Skin, gills, and fins.
Tetracotyle sp.	Pericordial cavity, pericordium and renal peritoneum.
Dibothriocephalus sp.	Wall of stomach and intestine body wall or free in the body cavity.
Schistocephalus solidus (Creplin, 1829)	Plerocercoids found in the stomach.
Eubothrium salvelini Schrank, 1790	Pyloric region and caecae.
Echinorhynchus lateralis Leidy, 1851	Intestine, sometimes pyloric caeca.
Philonema sp.	Body cavity.
Metabronema salvelini Fujeta, 1920	Esophagus, stomach intestine, and liver.
Salmincola sp.	Gills, opercula, and fins.
Argulus canadensis Wilson, 1916	External surface

found in Terra Nova Lake, Gambo Pond, and Rambler Pond. Dibothriocephalus sp. was found only on the Avalon and Burin Peninsulas, Bonavista Bay, and central Newfoundland. Argulus canadensis was found only in the Ocean Pond area (Mahers). Bunodera luciopercae was found only at Bonne Bay Big Pond. Philonema sp. was found only in the Grand Lake watershed.

Table X: 2 lists the 17 parasites encountered by Pippy (1965) and the corresponding percentages of infestation by each. In this survey only five macroscopic parasites were encountered. These include an Acanthocephala, Echinorhynchus lateralis; the cestode, Eubothrium salvelini; the digenetic trematode, Apophallus sp.; the copepod, Salmincola sp.; and the nematode, Philonema sp.

Table X: 3 shows the extent of parasitism by each organism for all localities studied.

A. Echinorhynchus lateralis Leidy 1851.

These spiny-headed worms are found mainly in the lower intestine and at times as far anterior as the pyloric caeca. The parasite is attached by means of a proboscis bearing numerous recurved hooks. The parasite has no digestive tract and the digested food of the host is absorbed directly through the body surface of the worm.

These were the most common of the speckled trout parasites encountered. They were found in trout from all sampling areas and the per cent occurrence ranged from 5.0 to 96.2. Overall, this parasite occurred in 75.5 per cent of all speckled trout examined. Pippy (MS) found this parasite in 81.7 per cent of all speckled trout and found it to be the most common. Richardson (1936) reports finding this organism in the gut of every trout examined from Lake Edward, Quebec.

TABLE X: 2. The parasites of Newfoundland speckled trout and the percentage of infestation by each (from Pippy MS, 1965).

PARASITE	PER CENT OF TROUT INFESTED
Echinorhynchus lateralis	81.7
Crepiodostumum farionis	62.6
Apophallus sp.	61.1
Metabronema salvelini	31.3
Salmincola sp.	27.5
Eubothrium salvelini	25.2
Phyllodistomum sp.	15.3
Dibothriocephalus sp.	7.6
Tetracotyle sp.	7.6
Discocotyle salmonis	7.6
Philonema sp.	Trace
Argulus canadensis	Trace
Azygia longa	Trace
Bunodera luciopercae	Trace
Trichophyra piscium	Trace
Ichthyophthirius sp.	Trace
Schistocephalus solidus	Trace

TABLE X: 3. The parasites of speckled trout showing the per cent infestation for the various localities studied.

LOCALITY	PER CENT OF THE TROUT INFESTED				
	Echinorhynchus lateralis	Eubothrium salvelini	Apophallus sp.	Philonema sp.	Salmincola sp.
Stephen's Pond	96.2	43.3	72.1	—	—
Angle Pond	80.9	58.2	48.2	—	—
Thomas' Pond	92.4	29.5	5.7	—	—
Big Bear Cave Pond	70.5	17.2	76.2	—	35.2
Berry Hill Pond	92.9	—	82.1	—	—
Indian Bay Big Pond	77.0	81.0	74.0	11.0	44.0
Indian River (Stream-resident)	44.2	—	28.4	—	12.6
Indian River (Sea-run)	5.0	10.0	15.0	—	5.0
GRAND AVERAGE	75.5	32.3	54.3	1.5	13.1

Frost (1940) also reports the presence of this parasite and suggests river trout usually have far less of these parasites then pond trout. This is in agreement with data from this study. In ponds, the per cent occurrence ranged from 70 - 96, while only 44 per cent of river trout were infected (Table X: 3).

The worms reach sexual maturity in the fish, eggs are produced by mature females and leave the host via the feces. Each egg contains a larval

acanthor which is incapable of hatching unless injested by an arthropod (probably an amphipod, Hyallela sp.). The larva develops in the gut of the amphipod and is liberated into the digestive tract of the trout which swallows the amphipod.

Frost (1940) suggests that the greatest number of Acanthocephalae is often found in the most healthy and best-conditioned fish, and she suggests the trout are little the worst for their presence. Hoffman and Sindermann (1962) suggest that unless extremely large numbers are present little damage is done. Pippy (MS) also found little evidence of damage during his study.

However, Davis (1937) states that the worms may cause an infection resulting in severe inflamation, and in 1953 he suggested Newfoundland trout were so heavily infested that they must have been badly injured.

Meyer (1954) suggests the proboscis causes damage to the intestinal wall with resulting ulcer-like lesions and conspicuous areas of laceration and inflammation. He suggests they may burrow through the wall of the digestive tract and come to lie in the body cavity, or undergo encystment in the viscera.

Although Pippy himself did not encounter damage due to infestation, he had a report of serious damage from a high infestation of trout in Rambler Pond, Baie Verte Peninsula. Here many trout were found to have their intestines dangling through a gaping hole in the body wall. Acanthocephala were thought to have worked their way through the intestinal wall, attached themselves to the peritoneum, and broke through the body wall.

In this study, damaged viscera was encountered in trout from Angle Pond and Big Bear Cave Pond. In these cases the damage was similar to that

attributed to the roundworm, Philonema sp. by various authors (Richardson, 1930; Meyer, 1954; Hoffman and Sindermann, 1962; and Pippy, 1965).

Pippy (MS) reports such damage to the viscera and attributes it to the philometrid nematode or plerocercoids of the cestode Dibothriocephalus sp. The diagonistic feature he used was cysts containing either coiled Philonema sp. or plerocercoids of the cestode.

However, in this study no such cysts were found and neither Philonema sp. nor Dibothriocephalus sp. were present; the only other intestinal parasite which could be incriminated was Echinorhychus lateralis. This seems reasonable in the light of evidence offered by Meyer (1954) and Davis (1937).

In severe cases the viscera was bound into a solid mass by multiple adhesions of the peritoneum and the mesentaries. These adhesions not only bind the viscera together but also attach the visceral mass to the body wall. Some cases were so severe that difficulty was encountered in removing the stomach for food analysis. Three large females from Angle Pond and two from Big Bear Cave Pond were damaged to the extent that they were egg-bound. The walls of the ovaries were greatly thickened and attached to the other viscera. The ovaries were irregular in shape and the ova were irregular in size.

B. Eubothrium salvelini Schrank 1790.

This small cestode is generally found in the pyloric region with its scolex usually deep in the caecum. The body protrudes in loops hanging from the caeca into the stomach cavity. It is occasionally found more posterior in the intestine.

These miniature tapeworms attach by their scoleces and food is absorbed through the body surface from the contents of the host's stomach or intestine.

Eubothrium salvelini occurred in all but two samples of trout. In areas in which they occurred, the per cent occurrence ranged from approximately 10 - 80, with an overall 32 per cent occurrence (Table X: 3). Pippy (MS) reports 25.2 per cent occurrence in his comprehensive study.

Hunter and Hunter (1930) state that approximately 20 per cent of speckled trout in northern New York state were infected.

Frost (1940) suggests this parasite was Abothrium crassum (Bloch, 1779). Both Cooper (1918) and Hunter and Hunter (1930) report A. crassum in speckled trout. However, Wardle (1932) and Kuitunen-Ekbaum (1933) have shown that both the European Abothrium and North American Eubothrium are the same, and Eubothrium salvelini is now accepted.

Richardson (1936) suggests that although the infestation may be severe enough to apparently block the pyloric region, no apparent harm is done. However, Wardle (1932) records an almost epidemic mortality among the young of Dolly Varden char, Salvelinus alpinus malma.

Hunter and Hunter (1930) suggest trout taken from streams are free of this parasite. Table X: 3 shows that the parasite was not present in Indian River stream trout. However, Indian River sea-run trout show a 10 per cent occurrence. The parasite was probably picked up during the trouts' upward migration which take them through the Indian Ponds before reaching the headwaters of Indian River.

Meyer (1954) suggests that despite its abundance in salmonids nothing is known of the life cycle. He reports that the smelt was examined by Ward as a possible host for the plerocercoid larvae, with negative results.

C. Apophallus sp.

This parasite gives rise to what is commonly called "black-spot"

disease. These parasites are encysted in the skin, gills, and fins and give the fish a peppered appearance.

The black spot is a concentration of black pigment caused by the presence of trematode metacercaria in the skin of the fish. The "black-spot" infestations of speckled trout have been found to be due to a member of the family Heterophyidae, which are digenetic trematodes (Meyer, 1954). Earlier, Ricker (1932) suggested the metacercaria belonged to the family Strigeidae which cause "black-spot" in many other species of fish. However, it is now known that it is the family Heterophyidae, and Miller (1941) suggests the speckled trout is the natural host.

Meyer (1954) suggests the incriminated species is Apophallus imperator, however, Pippy (MS) suggests the Newfoundland species may not be imperator.

This parasite is apparently quite common in Newfoundland as it was encountered in all localities studied. The per cent occurrence ranged from approximately 6 - 82 and averaged 54.3 per cent overall. Pippy (MS) gives 61.1 as the per cent occurrence during his study.

Because the parasite is digenetic, its life cycle is somewhat complex, requiring more than one host. The adult trematode lives in the intestine of a fish-eating bird (merganser, loon, kingfisher, or gull). The adults mature, produce eggs which are released through the feces. These eggs contain miracidia which must be swallowed by, or burrow into, certain species of snails (probably Amnicolidae) to complete their development. After a month or two an enormous number of cercariae escape; these must now reach the right species of fish and then burrow into the skin. Each larva surrounds

itself with a thin wall, and in a reaction against this, the fish surrounds this cyst with black pigment cells and the black-spot results. When the fish is eaten by the right species of bird the cyst breaks down and the young parasite escapes into the intestine of the bird, matures, produces eggs, and the cycle is complete.

Often a speckled trout will be captured that appears as if it were heavily sprinkled with large grains of pepper. This fish had probably swam into a swarm of emerging cercariae and a great number penetrated the flesh simultaneously. Although the infestation may be high, no ill effects are shown (Pippy, MS).

D. Salmincola sp.

This parasite is one of the so-called "fish lice". It is an ectoparasitic copepod which may be found on the gills, opercula, and fins, attached under the skin by means of an attachment bulb.

This parasite occurred in 4 out of eight samples and does not appear to be as prevalent as those parasites already considered. In areas in which it occurred it was present in 5-44 per cent of the fish and had an overall per cent occurrence of 13.1 per cent.

Pippy (MS) reports it occurred in 27.5 per cent of the trout he examined.

Frost (1940) suggests they are seldom numerous. She suggests they are Salmincola edwardsii, which is also suggested by Ricker (1932), Savage (1935), and Meyer (1954). Savage (1935) suggests Salmincola edwardsii is specific on speckled trout. However, Pippy (MS) doubts that the Newfoundland species is edwardsii.

The life cycle of this organism is quite simple. The adult female produces eggs in two large egg sacs. These eggs are shed and soon hatch. The young copepod nauplius is now free to search for a host. The nauplius has two powerful swimming appendages. There are powerful rasping mouth parts under the head, ventrally. The attachment bulb and tube are also ventral in position. When the nauplius finds a host it rasps a hole and inserts the attachment bulb. The swimming appendages are lost, the rasping appendages degenerate, and segmentation disappears. In this condition the female is fertilized by a diminutive male which later dies and falls off. In about eight to ten weeks the eggs are shed and the adult female dies. The young nauplius usually has only a few hours to find a host and for this reason infestation is aided by overcrowded fish populations.

Meyer (1954) suggests that when occurring in large numbers, this parasite does considerable damage and may cause death. Savage (1935) suggests that in serious cases the gill covers may not be able to close and the trout are forced to have their mouths open continuously except for an occasional snapping of the jaws. The head is often shaken violently to rid themselves of the parasites, at this stage death is not far away.

Savage (1935) reports that in flowing waters the infestation is not as heavy. Indeed, Indian River trout had the lowest infestation rate of all trout having this parasite.

E. Philonema sp.

These round worms or nematodes are found free in the body cavity, digestive tract, or encysted between the mesentaries or beneath the peritoneal lining of the cavity. Their presence results in the formation of multiple

mesenteric and peritoneal adhesions, which bind the viscera into a compact mass. Amongst these adhesions there are usually cysts which are whitish in color and through which the worm is visible, "coiled like a watchspring" as Kendall and Dence (1927) have noted.

This parasite was encountered only at Indian Bay Big Pond where it infested only 11 per cent of the trout.

Pippy (MS) reports it from only the Grand Lake watershed, where 18 out of 29 Birchy Lake trout were infested.

Richardson (1936) suggests only trout greater then 20 cm. are infested in Lake Edward, Quebec.

Both Richardson (1936) and Meyer (1959) suggest sterility may occur because of the adhesions. Indian Bay Big Pond trout, although possessing adhesions, did not show evidence of sterility.

Meyer (1954) identifies the parasite as Philonema agubernaculum, however, Richardson (1936) suggests the Quebec species is unique and he tentatively named it P. salvelini.

Pippy (MS) suggests the Newfoundland species is perhaps neither of the two.

Meyer (1954) reports that the life cycle of P. agubernaculum is not known.

Richardson (1936) suggests that despite the severity of the infection and the condition of the viscera, the trout show no external indication of their condition.

F. Argulus canadensis Wilson, 1916.

Pippy (MS) reports this "fish louse" from the Ocean Pond area only. In this study, sampling at Angle Pond, nearby, did not yield this parasite.

Although not encountered during the course of this study, it is of interest to mention that the author has observed this parasite infesting both speckled trout and landlocked salmon at Petty Harbour Forest Pond and Topsail Three Island Pond. The parasite is seasonal and adults are readily seen crawling over the external body surface during July and August.

In summary, it can be said that a speckled trout which is parasite-free is indeed rare. Of the major parasites considered in this study, only Salmincola sp. has definitely been shown to cause death (Savage, 1935; and Meyer, 1954). The severe damage caused by Echinorhynchus lateralis, Philonema sp. and Dibothriocephalus sp. undoubtedly weakens a fish to such an extent that even if death isn't a direct result the fish is probably easy prey for predators.

A heavily parasitized trout has little aesthetic value to the angler, however, this does not deter any from the food value as none of the parasites considered are harmful to man.

PART XI: SUMMARY AND CONCLUSIONS

The provinces' freshwater piscine fauna is sparse due to past glaciation and geographical location. The only game fishes present are those of the family Salmonidae. These include the anadromous and landlocked Atlantic salmon, the anadromous and landlocked Arctic char, the two exotic salmonids, the brown trout and rainbow trout. Finally, there is the speckled trout in its anadromous and freshwater forms.

Speckled trout are generally distributed in the Province, and bear the brunt of the angling pressure. It is somewhat unusual then, that a species so widespread and so important should have had as little investigation in Newfoundland when compared with its mainland counterpart.

Nancy Frost during 1936-38 carried out a cursory examination of the ecology of Avalon Peninsula trout, and in 1964 Scott and Crossman, in a study of the freshwater fishes of the Province, compiled all available data up to that time.

The aim of the study was to add to scanty information on the species in this area.

Because little work of even a general nature had been done, this study set out to examine some of the broader aspects of the biology of speckled trout.

The study was divided into two main categories. Firstly, because the speckled trout is so widespread and has formed what would appear to be

many localized populations, one of the aims was to determine if indeed population differences do exist due to geographical separation, and if so, to what extent. This aspect dealt mainly with a consideration of meristics.

The second broad aim was an examination of the species in all of its natural habitats. Because the piscine fauna is sparse, speckled trout occupy niches in varying sizes and types of bodies of water. This aspect dealt mainly with a consideration of age and growth.

Also considered were some aspects of its life history and ecology such as reproduction, parasites, and food.

Size Composition

Generally, as the size of the body of water increases, the size distribution shifts to the right, and the degree of skewness increases, indicating both an increase in mean size, modal size, and range. This is in agreement with Ricker and Scott and Crossman, who suggest that the maximum size attainable is correlated indirectly with the size of the body of water, and directly with the presence of larger food organisms in the larger bodies of water.

No sexual dimorphism in size was exhibited.

Age Determination

A knowledge of the age composition of a fish population is essential to any study because of its importance in determination of such factors as life span, growth rate, fecundity, and age at first spawning.

Aging involved the interpretating of the annual markings or layers deposited on the scale and otolith respectively. This method is dependent on

changes in growth rate or metabolism during certain periods of the year as witnessed in these hard parts.

Aging speckled trout by their scales has long been validated for other areas, and was indirectly validated for this area through back-calculation of growth of different year classes. Comparable results from the use of otoliths has indirectly validated this structure.

Age Composition and Mortality

In Newfoundland waters, as in other areas, the age range of speckled trout is narrow in comparison with other members of the same genus, and with other trouts of the genus Salmo sp.

Speckled trout appear to have a short life span and it is apparent that the upper limit of age is governed by the size of the body of water. A general statement might be that longevity is related to increased spatial allotments.

There was no difference in age composition between the sexes.

Total mortalities were obtained from age composition using the methods of Jackson. Total annual mortality rates ranged from a low of 35% to a high of 95% and generally reflected angling pressure.

There was no evidence of differential mortality between the sexes.

Growth

Generally, the growth pattern in Newfoundland waters parallels the almost universal situation found elsewhere in its range, or as Scott and Crossman suggest, "Growth data exemplify the direct relationship of growth rate with habitat area", that is, "a steady increase in growth rate from brook to pond to lake".

The contrasting growth rates of sea-run and non-anadromous trout were shown quite clearly. Meristics indicate no genetic difference between the two populations and suggest the stream-resident fish are a combination of sea-run parr and smolt and a resident non-migratory stock. If we suppose these two groups to be genetically similar, the marked change in growth is environmentally induced, perhaps due to increased quality and quantity of food, and the influence of the space factor.

There was a slight tendency for males to be larger than females at the same age.

The age-length data were fitted to Walford transformations and L_∞'s were calculated. L_∞ values ranged from 12 to 25 inches, or in terms of weight, ½ lb. to 6 lbs. Maximum sizes attainable were again related to habitat size.

Frost suggests that because of the unavailability of larger foods, large trout would not be expected to be found in Newfoundland, a relatively slow growth rate should be general. In order to make the comparison of data between Newfoundland waters and those of the rest of North America valid, it was decided to compare the growth rates of trout from similar habitats. Generally speaking, the growth rate of Newfoundland speckled trout found in small bodies of water is comparable with that of its mainland counterpart in a similar habitat. However, in larger bodies of water, mainland trout show a much faster growth rate.

The length weight relationship was also determined for Newfoundland trout, and the cube law was closely followed with n values ranging from 2.5 - 3.2.

Unlike growth per se, weight as a function of length does not bear a direct positive relationship with the habitat size. The ratio increases in favor of weight as the habitat changes from stream to small pond, but from small pond to lake, the ratio of weight to length decreases. That is, in simplest terms, the ratio of weight to length reaches a maximum or optimum and then decreases as the habitat progresses in size from stream to lake.

The suggested reasons for such marked changes between habitats are environmental. In streams, trout suffer from overcrowding and low productivity. With an increase in habitat size, there is a corresponding increase in space and productivity. In lakes, productivity again decreases, and the ratio of weight to length decreases.

The seasonal change in the relationship was studied in one pond over the summer months. There was an increase in the weight to length ratio with passage of spring into fall. This is thought to be due to increased food intake and growth in early summer and maturation of gonads in the fall.

Condition factors were calculated to indicate the suitability of the different habitats. As was the case with the length weight relationship, the mean condition coefficient bears a direct relationship with the habitat size, with a positive relationship existing up to a certain optimum acreage and then an inverse relationship with further increase in acreage.

The reasons for such changes were discussed earlier with respect to changes in the length-weight relationship.

The condition factor was found to either increase or decrease with increase in length. The normal situation is for condition factors to increase with size, a decrease indicates a deficiency or limitation of the environment. There was no evidence of difference in values between the sexes.

Meristics

Meristic characters can be described simply as those parts that differ in number among fish of the same species. Meristic characters act as an indicator of identity and natural affinity of a species and are therefore used to separate races of populations.

In this study, four meristic characters were used, these include vertebrae, gill rakers, dorsal and anal fin rays.

Vertebral counts were generally found to follow Jordan's Rule, with an increase in number from south to north.

There was no apparent sexual dimorphism in vertebral number.

Jordan's Rule also was evident in a comparison of counts from Newfoundland and other North American localities.

In considering the use of gill rakers as useful characters, it was found that the count for the right side was significantly higher ($p < 0.01$) than for the left. It was also shown that total gill raker number is linearly correlated to fish length. For this reason, valid geographical comparisons can only be made using fish of the same length.

No sexual dimorphism was apparent in gill raker number.

Unlike vertebral numbers, gill raker numbers were found to be lower for Newfoundland trout than for mainland relatives; this is supposedly because of the smaller overall size of Newfoundland trout.

No significant correlation was found between dorsal or anal ray number and size, and no sexual dimorphism was evident. There was no consistent latitudinal variation, and Newfoundland counts were similar to those of other mainland localities.

Using meristics, no genetic differences were found between sea-trout and non-anadromous trout.

Sex and Sexual Maturity

It was found that under natural conditions, there was little deviation from the 1:1 sex ratio.

It was found that males tend to mature at an earlier age and smaller size than do females. Generally, 50% of males are mature at age 2^+ and 50% of females at age 3^+.

Generally, trout of the older age groups are at a more advanced stage of maturity than are trout of the younger age groups at any one time. This therefore implies that the older individuals should spawn a little earlier than the slower maturing younger fish.

There exists in all piscine species a direct relationship between size of females and the number of eggs produced. In this study, the relationship between egg number and length, weight, and age was studied in some detail. The relationship between fecundity and length was found to approximate the cube law, with fecundity proportional to the cube of the length.

Fecundity was found to be proportional to the weight, and to the square of the age.

Food

Food analysis was by three basic methods: weight, number, and occurrence.

Generally, the constituents of the speckled trout's diet are similar in most areas studied, even though their relative importance in the diet may vary from locality to locality.

Generally, the food includes the adults, larvae, and pupae of terrestrial insects; the larvae, adults, and nymphs of aquatic insects, amphipods, gastropods, ostracods, annelids, and forage fish.

The relative amounts of food found in the stomachs of trout from different localities indicate that the total weight of food per gram of fish increases with increased habitat size up to a maximum and then decreases. This is undoubtedly related to the higher productivity of small and medium sized ponds over streams and lakes.

Generally, it was found that benthic organisms are utilized relatively more than either pelagic or terrestrial forms.

No food was found in the stomachs of 20 sea-run trout taken after a long period in freshwater.

A comparison of the food eaten by speckled trout of different size indicates that no fish appears in the diet of trout under 15 cm., some between 15-25 cm., and above 25 cm. fish forms the bulk of the diet. No other food organisms show such a trend.

Generally, there is a decrease in food intake from spring to fall, with the heaviest feeding in early summer.

Parasites

Only parasites of a macroscopic variety were of concern in this study, and only five were encountered.

The infestation of speckled trout by these parasites ranged from 35 - 100 per cent.

The most common parasites were Echinorhynchus lateralis, and Apophallus sp. which occurred in all areas studied, and Eubothrium salvelini, which

occurred in all but one area. Also common was the fish louse Salmincola sp. The known range of Philonema sp. and Argulus canadensis was extended as Philonema sp. was encountered in one Indian Bay Pond, and Argulus canadensis was located in several Avalon Peninsula ponds.

Only Salmincola sp. has been shown to cause death directly, however, death may be indirectly caused through infestation by Echinorhynchus lateralis or Philonema sp.

None of the parasites encountered are harmful to man.

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APPENDICES

APPENDIX I

Table 1. Length composition of speckled trout from various localities in Newfoundland for both
(Standard deviation and standard errors calculated from actual frequencies shown in pa

LENGTH CLASS (cm.)	PERCENTAGE OF FISH					
	BERRY HILL POND			STEPHEN'S POND		
	Male	Female	Combined	Male	Female	Combined
5.55 - 7.55	-	-	-	-	-	-
7.55 - 9.55	-	-	-	-	-	-
9.55 - 11.55	1.88(1)	-	1.19(1)	-	-	-
11.55 - 13.55	7.54(4)	6.45(2)	7.14(6)	2.43(1)	1.58(1)	1.92(2)
13.55 - 15.55	33.96(18)	29.03(9)	32.14(27)	2.43(1)	4.76(3)	3.84(4)
15.55 - 17.55	32.07(17)	22.58(7)	28.57(24)	34.14(14)	22.22(14)	26.92(28)
17.55 - 19.55	13.20(7)	16.12(5)	14.28(12)	39.02(16)	31.74(20)	34.61(36)
19.55 - 21.55	7.54(4)	9.67(3)	8.33(7)	14.63(6)	17.46(11)	16.34(17)
21.55 - 23.55	1.88(1)	12.90(4)	5.95(5)	7.31(3)	19.04(12)	14.42(15)
23.55 - 25.55	1.88(1)	-	1.19(1)	-	-	-
25.55 - 27.55	-	3.23(1)	1.19(1)	-	1.58(1)	0.96(1)
27.55 - 29.55	-	-	-	-	1.58(1)	0.96(1)
29.55 - 31.55	-	-	-	-	-	-
31.55 - 33.55	-	-	-	-	-	-
Totals	100 (53)	100 (31)	100 (84)	100 (41)	100 (63)	100 (104)
Mean length	16.29	17.52	16.74	18.21	19.22	18.82
Range	10.3 - 25.0	11.7 - 25.9	10.3 - 25.9	12.0 - 23.5	13.0 - 29.0	12.0 - 29.0
Std. Dev.	2.632	3.496	2.988	2.092	2.872	2.720
Std. Error	0.361	0.627	0.326	0.326	0.361	0.266

for both sexes combined and separated.
own in parentheses).

FISH IN EACH CLASS						
	ANGLE POND			THOMAS' POND		
ined	Male	Female	Combined	Male	Female	Combined
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	2.08(1)	1.61(1)	1.81(2)	-	-	-
.92(2)	4.16(2)	1.61(1)	2.72(3)	-	-	-
.84(4)	4.16(2)	4.83(3)	4.54(5)	4.25(2)	-	1.90(2)
.92(28)	4.16(2)	3.22(2)	3.63(4)	2.12(1)	3.44(2)	2.85(3)
.61(36)	14.58(7)	8.06(5)	10.90(12)	21.27(10)	20.68(12)	20.95(22)
.34(17)	35.41(17)	27.41(17)	30.90(34)	40.42(19)	44.82(26)	42.85(45)
.42(15)	20.83(10)	32.25(20)	27.27(30)	19.14(9)	25.86(15)	22.85(24)
-	2.08(1)	17.74(11)	10.90(12)	12.76(6)	3.44(2)	7.61(8)
.96(1)	4.16(2)	1.61(1)	2.72(3)	-	1.72(1)	0.95(1)
.96(1)	2.08(1)	1.61(1)	1.81(2)	-	-	-
-	2.08(1)	-	0.90(1)	-	-	-
-	4.16(2)	-	1.81(2)	-	-	-
(104)	100 (48)	100 (62)	100 (110)	100 (47)	100 (58)	100 (105)
.82	20.93	21.26	21.11	20.68	20.76	20.72
- 29.0	10.2 - 32.5	10.8 - 27.8	10.2 - 32.5	14.2 - 25.5	17.0 - 26.3	14.2 - 26.3
720	4.456	3.262	3.784	2.374	1.785	2.098
266	0.643	0.414	0.360	0.346	0.234	0.204

APPENDIX I

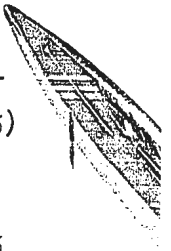
Table 1 (cont'd.)

LENGTH CLASS (cm.)	PERCENTAGE OF FIS					
	BIG BEAR CAVE POND			INDIAN BAY BIG POND		
	Male	Female	Combined	Male	Female	Combined
5.55 - 7.55	-	-	-	-	-	-
7.55 - 9.55	-	-	-	-	-	-
9.55 - 11.55	-	-	-	-	-	-
11.55 - 13.55	-	-	-	-	-	-
13.55 - 15.55	5.55 (3)	10.29 (7)	8.19(10)	-	-	-
15.55 - 17.55	35.18(19)	36.76(25)	36.06(44)	-	-	-
17.55 - 19.55	14.81 (8)	25.00(17)	20.49(25)	6.89 (4)	4.76 (2)	6 (6)
19.55 - 21.55	3.70 (2)	2.94 (2)	3.27 (4)	20.68(12)	16.66 (7)	19 (19)
21.55 - 23.55	3.70 (2)	5.88 (4)	4.91 (6)	24.13(14)	33.33(14)	28 (28)
23.55 - 25.55	5.55 (3)	-	2.45 (3)	15.51 (9)	19.04 (8)	17 (17)
25.55 - 27.55	9.25 (5)	8.82 (6)	9.01(11)	6.89 (4)	14.28 (6)	10 (10)
27.55 - 29.55	9.25 (5)	2.94 (2)	5.73 (7)	8.62 (5)	2.38 (1)	6 (6)
29.55 - 31.55	3.70 (2)	1.47 (1)	2.45 (3)	5.17 (3)	4.76 (2)	5 (5)
31.55 - 33.55	5.55 (3)	4.41 (3)	4.91 (6)	5.17 (3)	2.38 (1)	4 (4)
33.55 - 35.55	1.85 (1)	1.47 (1)	1.63 (2)	1.72 (1)	2.38 (1)	2 (2)
35.55 - 37.55	1.85 (1)	-	0.81 (1)	1.72 (1)	-	1 (1)
37.55 - 39.55	-	-	-	1.72 (1)	-	1 (1)
39.55 - 41.55	-	-	-	1.72 (1)	-	1 (1)
41.55 - 43.55	-	-	-	-	-	-
43.55 - 45.55	-	-	-	-	-	-
Totals	100 (54)	100 (68)	100 (122)	100 (58)	100 (42)	100 (100)
Mean length	21.70	19.73	20.60	24.92	24.02	24.55
Range	14.7 - 35.8	14.5 - 34.0	14.5 - 35.8	17.8 - 40.1	18.6 - 35.5	17.8 - 40.1
Std. Dev.	6.162	5.128	5.670	5.076	3.508	4.020
Std. Error	0.838	0.621	0.513	0.666	0.541	0.402

NDIX I

E OF FISH IN EACH CLASS

ND	INDIAN RIVER (Sea-run)			INDIAN RIVER (Stream-Resident)		
Combined	Male	Female	Combined	Male	Female	Combined
-	-	-	-	1.69 (1)	-	1.05 (1)
-	-	-	-	1.69 (1)	5.55 (2)	3.15 (3)
-	-	-	-	6.77 (4)	5.55 (2)	6.30 (6)
-	-	-	-	40.42(24)	30.55(11)	36.84(35)
-	-	-	-	23.73(14)	30.55(11)	26.31(25)
-	-	-	-	11.86 (7)	8.33 (3)	10.52(10)
6 (6)	-	-	-	10.16 (6)	13.88 (5)	11.57(11)
19 (19)	-	-	-	-	-	-
28 (28)	-	-	-	3.38 (2)	5.55 (2)	4.21 (4)
17 (17)	11.11 (1)	-	5.00 (1)	-	-	-
10 (10)	11.11 (1)	9.09 (1)	10.00 (2)	-	-	-
6 (6)	22.22 (2)	-	10.00 (2)	-	-	-
5 (5)	11.11 (1)	27.27 (3)	20.00 (4)	-	-	-
4 (4)	33.33 (3)	45.45 (5)	40.00 (8)	-	-	-
2 (2)	-	9.09 (1)	5.00 (1)	-	-	-
1 (1)	11.11 (1)	-	5.00 (1)	-	-	-
1 (1)	-	-	-	-	-	-
1 (1)	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	9.09 (1)	5.00 (1)	-	-	-
100 (100)	100 (9)	100 (11)	100 (20)	100 (59)	100 (36)	100 (95)
24.55	30.40	32.66	31.65	14.14	14.55	14.30
17.8 - 40.1	24.0 - 36.9	26.6 - 44.1	24.0 - 44.1	6.9 - 23.5	7.9 - 22.7	6.9 - 23.5
4.020	2.427	4.339	4.514	2.954	3.242	3.048
0.402	0.809	1.308	1.009	0.384	0.540	0.312



APPENDIX I

Table 1 (cont'd.)

LENGTH CLASS (cm.)	PERCENTAGE OF FISH IN EACH CLASS	
	TERRA NOVA LAKE	GANDER RIVER
	Sexes combined	Sexes combined
9.55 - 11.55	1.44 (1)	1.53 (1)
11.55 - 13.55	1.44 (1)	9.23 (6)
13.55 - 15.55	2.89 (2)	16.92(11)
15.55 - 17.55	7.24 (5)	24.61(16)
17.55 - 19.55	10.14 (7)	16.92(11)
19.55 - 21.55	11.59 (8)	18.46(12)
21.55 - 23.55	15.94(11)	12.30 (8)
23.55 - 25.55	13.04 (9)	-
25.55 - 27.55	15.94(11)	-
27.55 - 29.55	5.79 (4)	-
29.55 - 31.55	2.89 (2)	-
31.55 - 33.55	5.79 (4)	-
33.55 - 35.55	4.34 (3)	-
35.55 - 37.55	-	-
37.55 - 39.55	1.44 (1)	-
Totals	100 (69)	100 (65)
Mean Length	23.72	17.56
Range	11.5 - 37.8	11.2 - 22.6
Std. Dev.	5.646	3.144
Std. Error	0.679	0.393

APPENDIX I

Table 2. Whole weight composition of speckled trout from various localities in Newfoundland for both (Standard deviations and standard errors calculated from actual frequencies shown in parent

WEIGHT CLASS (gm.)	PERCENTAGE OF FIS.					
	INDIAN RIVER (Stream)			STEPHENS' POND		
	Male	Female	Combined	Male	Famale	Combined
0 - 10.55	3.38 (2)	5.55 (2)	4.21 (4)	-	-	-
10.55 - 40.55	62.71(37)	69.44(25)	65.26(62)	4.88 (2)	3.17 (2)	3.84 (4)
40.55 - 70.55	30.50(18)	11.11 (4)	23.16(22)	41.46(17)	30.15(19)	34.61(36)
70.55 - 100.55	-	8.33 (3)	3.16 (3)	34.14(14)	36.50(23)	35.57(37)
100.55 - 130.55	1.69 (1)	2.77 (1)	2.11 (2)	12.19 (5)	15.87(10)	14.42(15)
130.55 - 160.55	1.69 (1)	2.77 (1)	2.11 (2)	7.31 (3)	11.11 (7)	9.61(10)
160.55 - 190.55	-	-	-	-	-	-
190.55 - 220.55	-	-	-	-	-	-
220.55 - 250.55	-	-	-	-	1.58 (1)	0.96 (1)
250.55 - 280.55	-	-	-	-	-	-
280.55 - 310.55	-	-	-	-	1.58 (1)	0.96 (1)
310.55 - 340.55	-	-	-	-	-	-
460.55 - 490.55	-	-	-	-	-	-
490.55 - 520.55	-	-	-	-	-	-
520.55 - 550.55	-	-	-	-	-	-
Totals	100 (59)	100 (36)	100 (95)	100 (41)	100 (63)	100 (104)
Mean Weight	37.57	38.59	37.96	78.23	91.74	86.41
Range	5.5 - 152.1	7.0 - 134.5	5.5 - 152.1	23.0 - 141.0	27.0 - 288.0	23.0 - 288.0
Std. Dev.	23.640	33.600	26.394	29.835	44.490	39.750
Std. Error	3.078	5.600	2.708	4.660	5.605	3.897

for both sexes combined and separated.
in parentheses).

FISH IN EACH CLASS						
	BERRY HILL POND			ANGLE POND		
ined	Male	Female	Combined	Male	Female	Combined
-	-	-	-	-	-	-
.84 (4)	33.96(18)	22.58 (7)	29.76(25)	8.33 (4)	6.45 (4)	7.27 (8)
.61(36)	43.39(23)	38.70(12)	41.66(35)	6.25 (3)	9.67 (6)	8.18 (9)
.57(37)	15.09 (8)	19.35 (6)	16.66(14)	20.83(10)	11.29 (7)	15.45(17)
.42(15)	5.66 (3)	12.90 (4)	8.33 (7)	31.25(15)	29.03(18)	30.00(33)
.61(10)	-	3.22 (1)	1.19 (1)	18.75 (9)	27.41(17)	23.63(26)
.	1.88 (1)	-	1.19 (1)	2.08 (1)	9.67 (6)	6.36 (7)
.	-	3.22 (1)	1.19 (1)	2.08 (1)	3.22 (2)	2.72 (3)
.96 (1)	-	-	-	-	-	-
.	-	-	-	2.08 (1)	1.61 (1)	1.81 (2)
.96 (1)	-	-	-	-	1.61 (1)	0.90 (1)
.	-	-	-	2.08 (1)	-	0.90 (1)
.	-	-	-	4.16 (2)	-	1.81 (2)
.	-	-	-	-	-	-
.	-	-	-	2.08 (1)	-	0.90 (1)
(104)	100 (53)	100 (31)	100 (84)	100 (48)	100 (62)	100 (110)
.41	55.55	70.07	60.91	138.05	122.81	129.45
. 288.0	13.9 - 189.2	15.5 - 208.0	13.9 - 208.0	13.0 - 547.5	16.5 - 303.0	13.0 - 547.50
.750	30.570	40.890	35.190	102.660	51.960	81.330
.897	4.199	7.344	3.840	14.818	6.602	7.753

APPENDIX I

Table 2 (cont'd.)

WEIGHT CLASS (gm.)	PERCENTAGE OF FISH I						
	THOMAS' POND			BIG BEAR CAVE POND			
	Male	Female	Combined	Male	Female	Combined	Ma
10.55 - 40.55	4.25 (2)	-	1.90 (2)	1.85 (1)	1.47 (1)	1.63 (2)	
40.55 - 70.55	8.51 (4)	5.17 (3)	6.60 (7)	44.44(24)	54.41(37)	50.00(61)	1
70.55 - 100.55	23.40(11)	15.51 (9)	19.04(20)	9.25 (5)	17.64(12)	13.93(17)	22
100.55 - 130.55	34.04(16)	53.44(31)	44.76(47)	5.55 (3)	5.88 (4)	5.73 (7)	17
130.55 - 160.55	17.02 (8)	18.96(11)	18.09(19)	3.70 (2)	1.47 (1)	2.45 (3)	20
160.55 - 190.55	10.63 (5)	5.17 (3)	7.61 (8)	3.70 (2)	1.47 (1)	2.45 (3)	5
190.55 - 220.55	2.12 (1)	-	0.95 (1)	3.70 (2)	2.94 (2)	3.27 (4)	5
220.55 - 250.55	-	1.72 (1)	0.95 (1)	3.70 (2)	4.41 (3)	4.09 (5)	5
250.55 - 280.55	-	-	-	7.40 (4)	2.94 (2)	4.91 (6)	6
280.55 - 310.55	-	-	-	3.70 (2)	1.47 (1)	2.45 (3)	1
310.55 - 340.55	-	-	-	5.55 (3)	-	2.45 (3)	1
340.55 - 370.55	-	-	-	1.85 (1)	-	0.81 (1)	
370.55 - 400.55	-	-	-	-	-	-	
400.55 - 430.55	-	-	-	-	1.47 (1)	0.81 (1)	
430.55 - 460.55	-	-	-	1.85 (1)	1.47 (1)	1.63 (2)	
460.55 - 490.55	-	-	-	-	2.94 (2)	1.63 (2)	
490.55 - 520.55	-	-	-	-	-	-	
520.55 - 550.55	-	-	-	3.70 (2)	-	1.63 (2)	
550.55 - 580.55	-	-	-	-	-	-	
700.55 - 730.55	-	-	-	-	-	-	
1060.55 -1090.55	-	-	-	-	-	-	
Totals	100 (47)	100 (58)	100 (105)	100 (54)	100 (68)	100 (122)	10
Mean Weight	113.00	118.65	116.12	151.11	112.46	129.57	19
Range	28.0 - 200.5	53.8 - 221.0	28.0 - 221.0	38.0 - 549.0	39.0 - 485.1	38.0 - 549.0	69.0
Std. Dev.	39.960	30.600	35.040	129.660	105.840	97.350	13
Std. Error	5.828	4.018	3.419	17.641	12.829	8.810	1

PENDIX I

GE OF FISH IN EACH CLASS

'OND	INDIAN BAY BIG POND			INDIAN RIVER (Sea-run)		
Combined	Male	Female	Combined	Male	Female	Combined
) 1.63 (2)	-	-	-	-	-	-
) 50.00(61)	1.72 (1)	-	1.00 (1)	-	-	-
) 13.93(17)	22.41(13)	16.66 (7)	20.00(20)	-	-	-
) 5.73 (7)	17.24(10)	26.19(11)	21.00(21)	-	-	-
) 2.45 (3)	20.68(12)	16.66 (7)	19.00(19)	11.11 (1)	-	5.00 (1)
) 2.45 (3)	5.17 (3)	16.66 (7)	10.00(10)	-	-	-
) 3.27 (4)	5.17 (3)	11.90 (5)	8.00 (8)	11.11 (1)	9.09 (1)	10.00 (2)
) 4.09 (5)	5.17 (3)	-	3.00 (3)	11.11 (1)	-	5.00 (1)
) 4.91 (6)	6.89 (4)	2.38 (1)	5.00 (5)	-	-	-
) 2.45 (3)	1.72 (1)	4.76 (2)	3.00 (3)	11.11 (1)	27.27 (3)	20.00 (4)
2.45 (3)	1.72 (1)	-	1.00 (1)	11.11 (1)	9.09 (1)	10.00 (2)
0.81 (1)	-	-	-	33.33 (3)	9.09 (1)	20.00 (4)
-	5.17 (3)	-	3.00 (3)	-	18.18 (2)	10.00 (2)
) 0.81 (1)	-	2.38 (1)	1.00 (1)	-	18.18 (2)	10.00 (2)
) 1.63 (2)	-	-	-	-	-	-
) 1.63 (2)	-	-	-	-	-	-
-	1.72 (1)	-	1.00 (1)	-	-	-
1.63 (2)	-	2.38 (1)	1.00 (1)	-	-	-
-	3.44 (2)	-	2.00 (2)	11.11 (1)	-	5.00 (1)
-	1.72 (1)	-	1.00 (1)	-	-	-
-	-	-	-	-	9.09 (1)	5.00 (1)
) 100 (122)	100 (58)	100 (42)	100 (100)	100 (9)	100 (11)	100 (20)
129.57	191.58	165.55	181.05	314.02	406.42	364.55
. 38.0 - 549.0	69.0 - 703.8	72.4 - 538.5	69.0 - 703.8	156.0 - 557.5	205.5 - 1085.6	156.0 - 1085.6
97.350	137.10	89.310	120.93	120.000	231.300	190.530
8.810	18.002	13.782	12.093	40.000	69.732	42.603

APPENDIX I

Table 3. Gutted weight composition of speckled trout from various localities in Newfoundland for both sexes c
(Standard deviations and standard errors calculated from actual frequencies shown in parentheses).

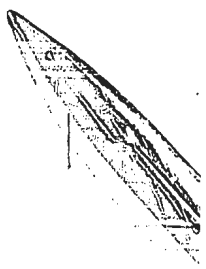
WEIGHT CLASS (gm.)	PERCENTAGE OF FISH IN						
	INDIAN RIVER (Stream)			STEPHENS' POND			
	Male	Female	Combined	Male	Female	Combined	Male
0 - 10.55	3.38 (2)	5.55 (2)	4.21 (4)	-	-	-	-
10.55 - 40.55	69.49(41)	72.22(26)	70.52(67)	4.87 (2)	4.76 (3)	4.80 (5)	45.28
40.55 - 70.55	23.72(14)	16.66 (6)	21.05(20)	51.21(21)	46.03(29)	48.07(50)	33.96
70.55 - 100.55	-	-	-	29.26(12)	25.39(16)	26.92(28)	15.09
100.55 - 130.55	1.69 (1)	5.55 (2)	3.15 (3)	14.63 (6)	19.04(12)	17.30(18)	3.77
130.55 - 160.55	1.69 (1)	-	1.05 (1)	-	1.58 (1)	0.96 (1)	1.88
160.55 - 190.55	-	-	-	-	1.58 (1)	0.96 (1)	-
220.55 - 250.55	-	-	-	-	1.58 (1)	0.96 (1)	-
250.55 - 280.55	-	-	-	-	-	-	-
280.55 - 310.55	-	-	-	-	-	-	-
310.55 - 340.55	-	-	-	-	-	-	-
340.55 - 370.55	-	-	-	-	-	-	-
370.55 - 400.55	-	-	-	-	-	-	-
400.55 - 430.55	-	-	-	-	-	-	-
430.55 - 460.55	-	-	-	-	-	-	-
460.55 - 490.55	-	-	-	-	-	-	-
Totals	100 (59)	100 (36)	100 (95)	100 (41)	100 (63)	100 (104)	100
Mean Weight	35.54	34.42	35.12	71.65	79.36	76.32	50.4
Range	5.0 - 139.0	7.0 - 134.5	5.0 - 139.0	19.0 - 123.0	23.0 - 237.5	19.0 - 237.5	12.9 -
Std. Dev.	23.262	33.600	23.595	24.279	35.400	31.830	28.6
Std. Error	3.029	5.600	2.421	3.792	4.458	3.121	3.9

: I

ınd for both sexes combined and separated.
ı in parentheses).

F FISH IN EACH CLASS

	BERRY HILL POND			ANGLE POND		
ıbined	Male	Female	Combined	Male	Female	Combined
-	-	-	-	-	-	-
4.80 (5)	45.28(24)	32.25(10)	40.47(34)	10.41 (5)	8.06 (5)	9.09(10)
48.07(50)	33.96(18)	38.70(12)	35.71(30)	6.25 (3)	8.06 (5)	7.27 (8)
26.92(28)	15.09 (8)	16.12 (5)	15.47(13)	37.50(18)	24.19(15)	30.00(33)
17.30(18)	3.77 (2)	9.67 (3)	5.95 (5)	22.91(11)	27.41(17)	25.45(28)
0.96 (1)	1.88 (1)	-	1.19 (1)	8.33 (4)	24.19(15)	17.27(19)
0.96 (1)	-	3.22 (1)	1.19 (1)	4.16 (2)	4.83 (3)	4.54 (5)
0.96 (1)	-	-	-	2.08 (1)	1.61 (1)	1.81 (2)
-	-	-	-	-	1.61 (1)	0.90 (1)
-	-	-	-	2.08 (1)	-	0.90 (1)
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	4.16 (2)	-	1.81 (2)
-	-	-	-	-	-	-
-	-	-	-	2.08 (1)	-	0.90 (1)
100 (104)	100 (53)	100 (31)	100 (84)	100 (48)	100 (62)	100 (110)
76.32	50.46	60.39	54.12	122.43	110.71	115.82
).0 - 237.5	12.9 - 156.7	14.0 - 190.1	12.9 - 190.1	11.5 - 471.1	15.5 - 267.0	11.5 - 471.1
31.830	28.662	35.280	31.560	74.190	46.470	72.180
3.121	3.937	6.336	3.444	10.709	5.901	6.885



APPENDIX I

Table 3 (cont'd.)

WEIGHT CLASS (gm.)	PERCENTAGE OF FISH I						
	THOMAS' POND			BIG BEAR CAVE POND			
	Male	Female	Combined	Male	Female	Combined	Mal
10.55 - 40.55	4.25 (2)	-	1.90 (2)	3.70 (2)	7.35 (5)	5.73 (7)	-
40.55 - 70.55	10.63 (5)	6.89 (4)	8.57 (9)	46.29(25)	54.41(37)	50.81(62)	5.
70.55 - 100.55	31.91(15)	36.20(21)	34.28(36)	7.40 (4)	13.23 (9)	10.65(13)	25.
100.55 - 130.55	34.04(16)	43.10(25)	39.04(41)	5.55 (3)	5.88 (4)	5.73 (7)	20.
130.55 - 160.55	12.76 (6)	12.06 (7)	12.38(13)	1.85 (1)	-	0.81 (1)	12.
160.55 - 190.55	6.38 (3)	-	2.85 (3)	5.55 (3)	4.41 (3)	4.91 (6)	6.
190.55 - 220.55	-	1.72 (1)	0.95 (1)	3.70 (2)	4.41 (3)	4.09 (5)	6.
220.55 - 250.55	-	-	-	7.40 (4)	2.94 (2)	4.91 (6)	6.
250.55 - 280.55	-	-	-	5.55 (3)	1.47 (1)	3.21 (4)	1.
280.55 - 310.55	-	-	-	5.55 (3)	-	2.45 (3)	·
310.55 - 340.55	-	-	-	1.85 (1)	-	0.81 (1)	3
340.55 - 370.55	-	-	-	-	1.47 (1)	0.81 (1)	3
370.55 - 400.55	-	-	-	1.85 (1)	1.47 (1)	1.63 (2)	
400.55 - 430.55	-	-	-	-	1.47 (1)	0.81 (1)	
430.55 - 460.55	-	-	-	1.85 (1)	1.47 (1)	1.63 (2)	3
460.55 - 490.55	-	-	-	-	-	-	
490.55 - 520.55	-	-	-	1.85 (1)	-	0.81 (1)	1
610.55 - 640.55	-	-	-	-	-	-	1
880.55 - 910.55	-	-	-	-	-	-	
Totals	100 (47)	100 (58)	100 (105)	100 (54)	100 (68)	100 (122)	10(
Mean Weight	103.42	105.72	104.69	138.88	101.43	118.01	17.
Range	24.6 - 180.0	46.0 - 199.0	24.6 - 199.0	35.1 - 501.5	35.7 - 434.5	35.1 - 501.5	4.6 ·
Std. Dev.	35.190	26.748	30.900	115.650	93.360	105.000	12
Std. Error	5.133	3.512	3.014	15.738	11.321	9.502	1

X I

OF FISH IN EACH CLASS

mbined	INDIAN BAY BIG POND			INDIAN RIVER (Sea-run)		
	Male	Female	Combined	Male	Female	Combined
5.73 (7)	-	-	-	-	-	-
50.81(62)	5.17 (3)	4.76 (2)	5.00 (5)	-	-	-
10.65(13)	25.86(15)	26.19(11)	26.00(26)	-	-	-
5.73 (7)	20.68(12)	23.80(10)	22.00(22)	-	-	-
0.81 (1)	12.06 (7)	16.66 (7)	14.00(14)	11.11 (1)	-	5.00 (1)
4.91 (6)	6.89 (4)	11.90 (5)	9.00 (9)	-	-	-
4.09 (5)	6.89 (4)	4.76 (2)	6.00 (6)	22.22 (2)	9.09 (1)	15.00 (3)
4.91 (6)	6.89 (4)	2.38 (1)	5.00 (5)	-	-	-
3.21 (4)	1.72 (1)	4.76 (2)	3.00 (3)	11.11 (1)	18.18 (2)	15.00 (3)
2.45 (3)	-	-	-	11.11 (1)	18.18 (2)	15.00 (3)
0.81 (1)	3.44 (2)	2.38 (1)	3.00 (3)	11.11 (1)	9.09 (1)	10.00 (2)
0.81 (1)	3.44 (2)	-	2.00 (2)	22.22 (2)	18.18 (2)	20.00 (4)
1.63 (2)	-	-	-	-	9.09 (1)	5.00 (1)
0.81 (1)	-	2.38 (1)	1.00 (1)	-	9.09 (1)	5.00 (1)
1.63 (2)	3.44 (2)	-	2.00 (2)	-	-	-
-	-	-	-	-	-	-
0.81 (1)	1.72 (1)	-	1.00 (1)	11.11 (1)	-	5.00 (1)
-	1.72 (1)	-	1.00 (1)	-	-	-
-	-	-	-	-	9.09 (1)	5.00 (1)
100 (122)	100 (58)	100 (42)	100 (100)	100 (9)	100 (11)	100 (20)
118.01	171.92	143.40	159.95	295.55	369.19	336.05
5.1 - 501.5	4.6 - 635.8	63.0 - 430.5	63.0 - 635.8	143.0 - 518.7	196.0 - 909.0	143.0 - 909.0
105.000	125.460	72.990	102.720	105.960	184.620	155.520
9.502	16.473	11.262	10.272	35.320	55.659	34.776

APPENDIX II

Table 1. Age-length relationship of speckled trout from various localities in Newfoundland.

AGE (yrs.)	AVERAGE FORK LE						
	BERRY HILL POND			STEPHENS' POND			
	Male	Female	Combined	Male	Female	Combined	M
I+	10.3 (1)	-	10.3 (1)	12.0 (1)	-	12.0 (1)	12
II+	14.8(30)	14.8(15)	14.8(45)	16.9(13)	16.4(15)	16.6(28)	19
III+	18.1(20)	18.9(12)	18.4(32)	19.1(26)	19.6(45)	19.4(71)	21
IV+	24.0(2)	23.2 (4)	23.5 (6)	23.5 (1)	24.0 (2)	23.8 (3)	30
V+	-	-	-	-	29.0 (1)	29.0 (1)	32
	BIG BEAR CAVE POND			INDIAN BAY BIG POND			
I+	14.7 (1)	14.5 (1)	14.6 (2)	-	-	-	
II+	17.4(30)	17.3(47)	17.3(77)	18.9(4)	18.8 (2)	18.9 (6)	12
III+	26.2(16)	24.6(16)	25.4(32)	22.1(33)	22.6(28)	22.3(61)	16
IV+	31.6 (6)	32.0 (3)	31.7 (9)	27.8(14)	26.6(10)	27.3(24)	22
V+	35.8 (1)	34.0 (1)	34.9 (2)	34.5 (6)	32.8 (2)	34.1 (8)	
VI+	-	-	-	40.1 (1)	-	40.1 (1)	
	GANDER RIVER			TERRA NOVA LAKE			
	(Sexes combined)			(Sexes combined)			
I+	11.5 (2)			11.8 (2)			
II+	14.6 (24)			17.3 (11)			
III+	19.4 (36)			22.6 (33)			
IV+	22.5 (3)			28.3 (18)			
V+	-			34.8 (5)			
VI+	-			-			
VII+	-			-			
VIII+	-			-			

i.

FORK LENGTH (cm.)

ied	ANGLE POND Male	Female	Combined	THOMAS' POND Male	Female	Combined
(1)	12.7 (4)	11.4 (2)	12.0 (6)	14.2 (2)	-	14.2 (2)
28)	19.2(17)	19.2(25)	19.2(42)	19.5(20)	19.5(27)	19.5(47)
71)	21.5(23)	23.1(34)	22.7(57)	23.0(25)	22.1(31)	22.1(56)
(3)	30.7 (3)	27.8 (1)	30.0 (4)	-	-	-
(1)	32.5 (1)	-	32.5 (1)	-	-	-

	INDIAN RIVER (Stream)			INDIAN RIVER (Sea-run)		
	7.4 (2)	8.7 (2)	8.1 (4)	-	-	-
(6)	12.7(31)	13.1(20)	12.9(51)	-	-	-
51)	16.3(24)	16.2(11)	16.2(35)	24.0 (1)	26.6 (1)	25.3 (2)
24)	22.7 (2)	21.1 (3)	21.7 (5)	28.9 (4)	30.5 (3)	29.6 (7)
(8)	-	-	-	33.5 (4)	32.8 (6)	33.1(10)
(1)	-	-	-	-	44.1 (1)	44.1 (1)

	INDIAN BAY PONDS (Prize-Trout) (Sexes combined)
	-
	-
	-
	-
	33.8 (6)
	39.6 (12)
	45.6 (5)
	48.5 (2)

APPENDIX II

Table 2. Calculated annual increments in length for speckled trout (sexes combined) from various localities in Newfoundland.

LOCALITY	AGES							
	0 - I+	I+ - II+	II+ - III+	III+ - IV+	IV+ - V+	V+ - VI+	VI+ - VII+	VII+ - VIII+
Indian River (Stream)	8.0	4.9	4.2	3.8	-	-	-	-
Gander River	11.1	4.5	3.4	2.9	-	-	-	-
Berry Hill Pond	10.1	5.0	4.0	3.5	-	-	-	-
Stephens' Pond	11.6	5.1	4.0	3.4	3.0	-	-	-
Angle Pond	12.1	6.5	5.3	4.7	4.3	-	-	-
Thomas' Pond	14.3	4.7	3.4	2.8	2.4	-	-	-
Big Bear Cave Pond	13.5	6.6	5.3	4.6	4.1	-	-	-
Indian Bay Big Pond	11.1	6.8	5.8	5.2	4.8	4.5	-	-
Terra Nova Lake	11.4	6.7	5.6	5.0	4.6	-	-	-
Indian River (Sea-run)	-	-	-	5.9	5.5	5.3	-	-
Indian Bay Ponds (Prize-trout)	-	-	-	-	5.5	5.3	5.1	5.0

APPENDIX II

Table 3. Calculated age-length relationship for speckled trout from various localities in Newf

AGE (yrs.)	CALCULATED AVERA					
	BERRY HILL POND			STEPHENS' POND		
	Male	Female	Combined	Male	Female	Combined
I+	10.1	9.4	10.1	12.0	10.4	11.6
II+	15.1	14.7	15.1	16.5	15.9	16.8
III+	19.2	19.1	19.1	20.0	20.5	20.8
IV+	22.7	23.0	22.6	22.9	24.4	24.2
V+	-	-	-	25.4	28.1	27.2
	BIG BEAR CAVE POND			INDIAN BAY BIG POND		
I+	13.6	13.4	13.5	11.1	12.2	11.1
II+	20.3	20.0	20.1	17.9	18.3	17.9
III+	25.8	25.1	25.5	23.7	23.3	23.7
IV+	30.5	29.5	30.0	29.0	27.6	28.9
V+	34.8	33.7	34.2	33.9	31.5	33.7
VI+	-	-	-	38.5	35.1	38.2

	GANDER RIVER	TERRA NOVA LAKE
	(Sexes combined)	(Sexes combined)
I+	11.1	11.4
II+	15.6	18.0
III+	19.1	23.6
IV+	22.0	28.5
V+	-	33.1
VI+	-	-
VII+	-	-
VIII+	-	-

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VERAGE FORK LENGTH (cm.)

	ANGLE POND			THOMAS' POND		
ombined	Male	Female	Combined	Male	Female	Combined
11.6	12.5	11.6	12.1	14.3	15.7	14.3
16.8	18.9	18.1	18.6	19.0	19.5	19.0
20.8	24.0	23.5	24.0	22.4	22.1	22.4
24.2	28.4	28.2	28.7	25.2	24.2	25.2
27.2	32.4	32.6	32.9	27.5	25.9	27.6

	INDIAN RIVER (Stream)			INDIAN RIVER (Sea-run)		
11.1	7.3	8.6	8.0	-	-	-
17.9	12.6	13.2	12.9	-	-	-
23.7	17.3	17.0	17.1	24.0	25.7	24.4
28.9	21.7	20.4	20.9	28.9	31.1	30.3
33.7	-	-	-	33.5	36.1	35.7
38.2	-	-	-	37.7	40.8	41.1

	INDIAN BAY PONDS (Prize-Trout)
	(Sexes combined)
	-
	-
	-
	28.6
	34.1
	39.4
	44.5
	49.4

APPENDIX II

Table 4. Calculated age-length relationships for speckled trout from various localities in Newfou (with corresponding standard errors of estimate).

	Log Regression Form	Exponential Form	Standard Error
	INDIAN RIVER (Stream-Resident)		
Male	Log L = 0.7806 Log A + 0.8656	$L = 7.338\ A^{.7806}$	1.025
Female	Log L = 0.6204 Log A + 0.9340	$L = 8.590\ A^{.6204}$	0.731
Combined	Log L = 0.6949 Log A + 0.9011	$L = 7.964\ A^{.6949}$	0.852
	STEPHENS' POND		
Male	Log L = 0.4690 Log A + 1.0772	$L = 11.95\ A^{.4690}$	0.810
Female	Log L = 0.6186 Log A + 1,0155	$L = 10.36\ A^{.6186}$	0.993
Combined	Log L = 0.5273 Log A + 1.0661	$L = 11.64\ A^{.5273}$	1.322
	THOMAS' POND		
Male	Log L = 0.4063 Log A + 1.1560	$L = 14.32\ A^{.4063}$	0.598
Female	Log L = 0.3097 Log A + 1.1967	$L = 15.73\ A^{.3097}$	0.601
Combined	Log L = 0.4080 Log A + 1.1560	$L = 14.32\ A^{.4080}$	0.604
	INDIAN BAY BIG POND		
Male	Log L = 0.6954 Log A + 1.0437	$L = 11.06\ A^{.6954}$	1.657
Female	Log L = 0.5904 Log A + 1.0857	$L = 12.18\ A^{.5904}$	1.282
Combined	Log L = 0.6919 Log A + 1.0440	$L = 11.07\ A^{.6919}$	1.720
	GANDER RIVER		
Combined	Log L = 0.4928 Log A + 1.0452	$L = 11.10\ A^{.4928}$	0.484

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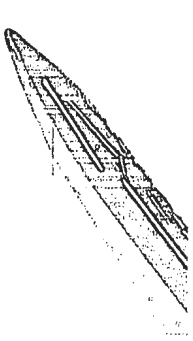
ror	Log Regression Form	Exponential Form	Standard Error
	BERRY HILL POND		
	Log L = 0.5862 Log A + 1.0035	$L = 10.08\ A^{.5862}$	1.198
	Log L = 0.6443 Log A + 0.9744	$L = 9.43\ A^{.6443}$	0.257
	Log L = 0.5783 Log A + 1.0053	$L = 10.13\ A^{.5783}$	0.817
	ANGLE POND		
	Log L = 0.5917 Log A + 1.0976	$L = 12.52\ A^{.5917}$	1.963
	Log L = 0.6394 Log A + 1.0657	$L = 11.63\ A^{.6394}$	0.870
	Log L = 0.6227 Log A + 1.0823	$L = 12.09\ A^{.6227}$	1.140
	BIG BEAR CAVE POND		
	Log L = 0.5847 Log A + 1.1325	$L = 13.57\ A^{.5847}$	2.036
	Log L = 0.5703 Log A + 1.1281	$L = 13.43\ A^{.5703}$	2.211
	Log L = 0.5773 Log A + 1.1302	$L = 13.50\ A^{.5773}$	2.037
	TERRA NOVA LAKE		
	Log L = 0.6650 Log A + 1.0551 (Combined)	$L = 11.35\ A^{.6650}$	1.132
	INDIAN BAY PONDS (Prize-Trout)		
	Log L = 0.7887 Log A + 0.9816 (Combined)	$L = 9.585\ A^{.7887}$	1.053



APPENDIX II

Table 5. Age-weight whole relationship of speckled trout from various localities in Newfoundland.

AGE (yrs.)	AVERAGE WHOLE					
	BERRY HILL POND			STEPHENS' POND		
	Male	Female	Combined	Male	Female	Combined
I+	13.9 (1)	-	13.9 (1)	23.5 (1)	-	23.5 (1)
II+	40.4(30)	38.3(15)	39.1(45)	63.3(13)	55.0(15)	58.9(28)
III+	72.7(20)	77.6(12)	74.6(32)	87.5(26)	94.4(45)	91.9(71)
IV+	155.6 (2)	144.9 (4)	148.4 (6)	130.9 (1)	182.7 (2)	165.4 (3)
V+	-	-	-	-	288.0 (1)	288.0 (1)
	BIG BEAR CAVE POND			INDIAN BAY BIG POND		
I+	38.0 (1)	41.0 (1)	39.5 (2)	-	-	-
II+	60.9(30)	60.8(47)	60.8(77)	80.6 (4)	74.2 (2)	78.4 (6)
III+	211.3(16)	180.0(16)	195.7(32)	132.5(33)	123.4(28)	127.6(61)
IV+	384.4 (6)	468.7 (3)	412.5 (9)	239.8(14)	218.3(10)	230.8(24)
V+	549.0 (1)	406.0 (1)	477.5 (2)	455.6 (6)	418.9 (2)	446.4 (8)
VI+	-	-	-	703.8 (1)	-	703.8 (1)

and.

LE WEIGHT (gm.)

ANGLE POND			THOMAS' POND		
Male	Female	Combined	Male	Female	Combined
24.3 (4)	19.3 (2)	22.6 (6)	30.3 (2)	-	30.3 (2)
91.8(17)	87.2(25)	89.0(42)	93.4(20)	100.1(27)	97.2(47)
135.4(23)	150.6(34)	144.8(57)	137.4(25)	133.0(31)	134.9(56)
421.5 (3)	303.0 (1)	391.9 (4)	-	-	-
574.5 (1)	-	574.5 (1)	-	-	-

INDIAN RIVER (Stream)			INDIAN RIVER (Sea-run)		
6.7 (2)	8.8 (2)	7.7 (4)	-	-	-
23.2(31)	25.2(20)	24.0(51)	-	-	-
47.3(24)	47.8(11)	47.4(35)	205.5 (1)	156.0 (1)	180.8 (2)
133.3 (2)	109.5 (3)	119.0 (5)	256.8 (4)	310.9 (3)	280.0 (7)
-	-	-	410.8 (4)	374.5 (6)	388.9(10)
-	-	-	-	1085.6 (1)	1085.6 (1)

APPENDIX II

Calculated age - weight whole relationships for speckled trout from various localities in Ne

Regression Form	Exponential Form	Standard Error	Log Regr
INDIAN RIVER (Stream)			
Log W = 2.0641 Log A + 0.7850	$W = 6.095\ A^{2.0641}$	20.65	Log W = 1.6
Log W = 1.7556 Log A + 0.9096	$W = 8.121\ A^{1.7556}$	13.33	Log W = 1.9
Log W = 1.8958 Log A + 0.8506	$W = 7.089\ A^{1.8958}$	16.28	Log W = 1.6
STEPHENS' POND			
Log W = 1.2138 Log A + 1.3890	$W = 24.49A^{1.2138}$	6.07	Log W = 1.9
Log W = 1.8270 Log A + 1.1595	$W = 14.46\ A^{1.8270}$	14.14	Log W = 1.9
Log W = 1.4985 Log A + 1.3333	$W = 21.54\ A^{1.4985}$	30.13	Log W = 2.0
THOMAS' POND			
Log W = 1.4065 Log A + 1.4982	$W = 31.49\ A^{1.4065}$	14.39	Log W = 1.7
Log W = 0.5612 Log A + 1.8438	$W = 69.79\ A^{0.5612}$	4.69	Log W = 1.6
Log W = 1.3964 Log A + 1.5040	$W = 31.92\ A^{1.5040}$	18.69	Log W = 1.6
INDIAN BAY BIG POND			
Log W = 2.0060 Log A + 1.2365	$W = 17.24\ A^{2.0060}$	52.94	
Log W = 1.8517 Log A + 1.2682	$W = 18.55\ A^{1.8517}$	41.21	Log W = 2.3
Log W = 2.0269 Log A + 1.2138	$W = 16.36\ A^{2.0269}$	58.04	

n Newfoundland (with corresponding standard errors of estimate).

Regression Form	Exponential Form	Standard Error
BERRY HILL POND		
= 1.6830 Log A + 1.1200	$W = 13.18\ A^{1.6830}$	16.01
= 1.9086 Log A + 1.0000	$W = 10.00\ A^{1.9086}$	5.43
= 1.6675 Log A + 1.1194	$W = 13.16\ A^{1.6675}$	12.47
ANGLE POND		
= 1.9677 Log A + 1.3543	$W = 22.61\ A^{1.9677}$	60.19
= 1.9405 Log A + 1.3013	$W = 20.01\ A^{1.9405}$	15.87
= 2.0015 Log A + 1.3307	$W = 21.41\ A^{2.0015}$	45.16
BIG BEAR CAVE POND		
= 1.7652 Log A + 1.4687	$W = 29.43\ A^{1.7652}$	43.30
= 1.6374 Log A + 1.5053	$W = 32.01\ A^{1.6374}$	97.75
= 1.6982 Log A + 1.4871	$W = 30.70\ A^{1.6982}$	56.56
INDIAN RIVER (Sea-Run)		
= 2.3988 Log A + 1.0495	$W = 11.20\ A^{2.3988}$ (COMBINED)	212.60

APPENDIX II

Calculated age - weight whole relationship for speckled trout from vario

rs.)	Calculated Average Weight Whole (Gm.)							
	BERRY HILL POND			STEPHENS' POND				
Male	Female	Combined		Male	Female	Combined	Male	F
13.2	10.0	13.2		24.5	14.5	21.5	22.6	
42.8	37.5	41.8		56.8	51.2	60.9	88.4	
83.8	81.4	82.2		92.9	107.4	111.8	196.3	
135.9	141.0	132.8		131.7	181.8	172.0	345.9	
- - -	- - -	- - -		172.8	273.3	240.3	536.7	
	BIG BEAR CAVE POND			INDIAN BAY BIG POND				
29.4	32.0	30.7		17.2	18.6	16.4	6.1	
100.0	99.6	99.6		69.2	65.8	66.7	25.5	
204.6	193.4	198.3		156.2	141.4	151.7	58.9	
340.0	309.8	323.2		278.2	243.2	271.7	106.6	
504.2	446.5	472.2		435.2	370.0	427.2	- - -	
- - -	- - -	- - -		627.5	511.9	618.1	- - -	

om various localities in Newfoundland

(Gm.)

	ANGLE POND			THOMAS' POND	
e	Female	Combined	Male	Female	Combined
6	20.0	21.4	31.5	69.8	31.9
4	76.8	85.7	83.5	103.0	84.0
3	168.7	193.0	147.7	129.3	148.0
9	294.8	343.4	221.4	151.9	221.2
7	454.6	536.7	302.9	172.2	302.1

	INDIAN RIVER (Stream)		INDIAN RIVER (Sea-Run) (Sexes Combined)
1	8.1	7.1	- - -
5	27.4	26.4	- - -
9	55.9	56.9	156.3
6	92.6	98.2	311.8
-	- - -	- - -	532.5
-	- - -	- - -	824.5

APPENDIX II

8.

Age - weight gutted relationship for speckled trout from various

(Yrs.)	Average Gutted Weight (Gm.)							
	BERRY HILL POND			STEPHENS' POND			ANGL	
	Male	Female	Combined	Male	Female	Combined	Male	Femal
	12.9 (1)	- - -	12.9 (1)	19.0 (1)	- - -	19.0 (1)	22.0 (4)	17.3
	36.4 (30)	35.4 (15)	36.1 (45)	57.7 (13)	48.5 (15)	52.8 (28)	82.1 (17)	78.5
	67.1 (20)	70.0 (12)	68.2 (32)	79.2 (26)	82.9 (45)	81.5 (71)	121.5 (23)	135.2
	134.4 (2)	130.4 (4)	131.7 (6)	116.0 (1)	150.3 (2)	138.8 (3)	376.0 (3)	267.0
	- - -	- - -	- - -	- - -	237.5 (1)	237.5 (1)	471.1 (1)	- - -
	BIG BEAR CAVE POND			INDIAN BAY BIG POND			INDI	
	35.1 (1)	38.0 (1)	36.6 (2)	- - -	- - -	- - -	6.1 (2)	7.9
	56.3 (30)	56.2 (47)	56.2 (77)	75.0 (4)	66.8 (2)	72.2 (6)	21.5 (31)	23.4
	194.5 (16)	162.6 (16)	178.5 (32)	111.6 (33)	119.5 (28)	115.3 (61)	43.7 (24)	42.5
	341.8 (6)	416.1 (3)	365.5 (9)	219.4 (14)	195.6 (10)	209.5 (24)	122.8 (2)	97.2
	501.5 (1)	365.5 (1)	433.5 (2)	405.6 (6)	352.3 (2)	392.2 (8)	- - -	- - -
	- - -	- - -	- - -	635.8 (1)	- - -	635.8 (1)	- - -	- - -

; from various localities in Newfoundland.

ght (Gm.)

ANGLE POND			THOMAS' POND		
Male	Female	Combined	Male	Female	Combined
22.0 (4)	17.3 (2)	20.4 (6)	26.3 (2)	- - -	26.3 (2)
82.1 (17)	78.5 (25)	80.0 (42)	86.1 (20)	88.2 (27)	86.0 (47)
21.5 (23)	135.2 (34)	129.7 (57)	123.9 (25)	118.2 (31)	120.7 (56)
76.0 (3)	267.0 (1)	348.8 (4)	- - -	- - -	- - -
71.1 (1)	- - -	471.1 (1)	- - -	- - -	- - -

INDIAN RIVER (Stream)			INDIAN RIVER (Sea-Run)		
6.1 (2)	7.9 (2)	7.0 (4)	- - -	- - -	- - -
21.5 (31)	23.4 (20)	22.2 (51)	- - -	- - -	- - -
43.7 (24)	42.5 (11)	43.3 (35)	196.0 (1)	143.0 (1)	169.5 (2)
22.8 (2)	97.2 (3)	107.4 (5)	244.9 (4)	291.9 (3)	265.1 (7)
- - -	- - -	- - -	388.1 (4)	352.5 (6)	366.7 (10)
- - -	- - -	- - -	- - -	909.0 (1)	909.0 (1)

APPENDIX II

39.

Calculated age - weight gutted relationship for speckled t:

(Yrs.)	Calculated Average Gutted				
	BERRY HILL POND			STEPHENS' POND	
Male	Female	Combined	Male	Female	Combined
12.3	9.5	12.3	20.3	13.6	18.2
38.4	34.6	38.3	49.5	45.6	51.6
74.8	73.8	74.4	82.3	92.3	95.2
121.0	126.4	119.2	120.5	152.3	146.9
- - -	- - -	- - -	160.4	224.4	205.6
	BIG BEAR CAVE POND			INDIAN BAY BIG POND	
27.3	29.8	28.5	15.6	18.3	15.3
91.8	91.1	91.2	62.4	62.6	61.2
186.6	175.1	180.1	140.2	128.6	137.7
308.8	278.5	291.9	249.0	214.3	244.8
456.3	399.0	427.5	388.7	318.4	382.6
- - -	- - -	- - -	559.5	439.9	551.2

IX 11

ckled trout from various localities in Newfoundland.

Gutted Weight (Gm.)					
ANGLE POND			THOMAS' POND		
Male	Female	Combined	Male	Female	Combined
20.8	18.1	19.7	27.4	53.2	27.7
78.8	68.9	76.2	74.3	88.1	74.4
172.0	150.8	168.2	133.0	118.3	132.3
299.3	262.6	295.2	201.2	146.0	199.3
459.8	403.8	456.5	277.3	171.7	273.6

INDIAN RIVER (Stream)			INDIAN RIVER (Sea-Run)
			(Sexes Combined)
5.5	7.4	6.5	- - -
23.4	24.8	24.0	- - -
54.4	50.2	51.9	150.3
99.2	82.8	89.5	288.5
- - -	- - -	- - -	478.0
- - -	- - -	- - -	722.4

APPENDIX II

s 10.

Calculated age-weight gutted relationships for speckled trout from various localities

	Log Regression Form	Exponential Form	Standard Error	Log
INDIAN RIVER (Stream)				
	Log W = 2.0800 Log A + 0.7430	$W = 5.53\ A^{2.0800}$	18.30	Log W =
le	Log W = 1.7411 Log A + 0.8698	$W = 7.41\ A^{1.7411}$	11.58	Log W =
ined	Log W = 1.8961 Log A + 0.8103	$W = 6.46\ A^{1.8961}$	14.09	Log W =
STEPHENS' POND				
	Log W = 1.2844 Log A + 1.3076	$W = 20.31\ A^{1.2844}$	7.31	Log W =
le	Log W = 1.7398 Log A + 1.1349	$W = 13.64\ A^{1.7398}$	11.67	Log W =
ined	Log W = 1.5074 Log A + 1.2593	$W = 18.17\ A^{1.5074}$	20.59	Log W =
THOMAS' POND				
	Log W = 1.4381 Log A + 1.4378	$W = 27.40\ A^{1.4381}$	12.75	Log W =
le	Log W = 0.7281 Log A + 1.7258	$W = 53.19\ A^{0.7281}$	0.02	Log W =
ined	Log W = 1.4221 Log A + 1.4432	$W = 27.74\ A^{1.4221}$	16.49	Log W =
INDIAN BAY BIG POND				
	Log W = 1.9969 Log A + 1.1938	$W = 15.63\ A^{1.9969}$	51.49	
le	Log W = 1.7741 Log A + 1.2628	$W = 18.31\ A^{1.7741}$	28.24	Log W =
ined	Log W = 2.0009 Log A + 1.1842	$W = 15.29\ A^{2.0009}$	55.15	

ties in Newfoundland (with corresponding standard errors of estimate).

Log Regression Form	Exponential Form	Standard Error
BERRY HILL POND		
; W = 1.6449 Log A + 1.0892	$W = 12.28\ A^{1.6449}$	10.99
; W = 1.8689 Log A + 0.9766	$W = 9.48\ A^{1.8689}$	5.64
; W = 1.6388 Log A + 1.0898	$W = 12.29\ A^{1.6388}$	10.02
ANGLE POND		
; W = 1.9239 Log A + 1.3178	$W = 20.79\ A^{1.9239}$	53.46
; W = 1.9283 Log A + 1.2583	$W = 18.12\ A^{1.9283}$	13.30
; W = 1.9541 Log A + 1.2936	$W = 19.66\ A^{1.9541}$	39.08
BIG BEAR CAVE POND		
g W = 1.7499 Log A + 1.4361	$W = 27.30\ A^{1.7499}$	38.77
g W = 1.6122 Log A + 1.4741	$W = 29.80\ A^{1.6122}$	84.67
g W = 1.6777 Log A + 1.4552	$W = 28.52\ A^{1.6777}$	47.69
INDIAN RIVER (Sea-Run) (Sexes Combined)		
›g W = 2.2639 Log A + 1.0970	$W = 12.50\ A^{2.2639}$	155.10

APPENDIX II

11.

Length - weight whole relationship for speckled trout from varic

Length (Gm.)	Average Whole Weight (Gm.)						
	BERRY HILL POND			STEPHENS' POND			
	Male	Female	Combined	Male	Female	Combined	Male
	13.9 (1)	- - -	13.9 (1)	- - -	- - -	- - -	13.(
	23.4 (4)	21.8 (2)	22.8 (6)	23.5 (1)	27.0 (1)	25.3 (2)	23.(
	38.3 (18)	38.1 (9)	38.2 (27)	35.0 (1)	41.6 (3)	40.0 (4)	38.8
	51.7 (17)	51.3 (7)	51.6 (24)	61.6 (14)	61.3 (14)	61.4 (28)	58.:
	79.7 (7)	73.0 (5)	77.7 (12)	79.6 (16)	76.2 (20)	77.7 (36)	92.'
	102.9 (4)	95.7 (3)	99.8 (7)	108.4 (6)	98.6 (11)	102.0 (17)	106.
	122.0 (1)	119.8 (4)	102.2 (5)	136.0 (3)	133.2 (12)	133.8 (15)	139.
	189.2 (1)	- - -	189.2 (1)	- - -	- - -	- - -	181.
	- - -	208.0 (1)	208.0 (1)	- - -	223.4 (1)	223.4 (1)	239.
	- - -	- - -	- - -	- - -	288.0 (1)	288.0 (1)	330.
	- - -	- - -	- - -	- - -	- - -	- - -	461.
	- - -	- - -	- - -	- - -	- - -	- - -	510.

, from various localities in Newfoundland.

ıt (Gm.)

ANGLE POND			THOMAS' POND		
Male	Female	Combined	Male	Female	Combined
13.0 (1)	16.5 (1)	14.8 (2)	- - -	- - -	- - -
23.6 (2)	22.0 (1)	23.0 (3)	- - -	- - -	- - -
38.8 (2)	39.9 (3)	39.4 (5)	30.3 (2)	- - -	30.3 (2)
58.1 (2)	54.4 (2)	56.2 (4)	60.0 (1)	54.6 (2)	56.4 (3)
92.9 (7)	77.4 (5)	86.4 (12)	81.2 (10)	91.7 (12)	86.9 (22)
106.6 (17)	104.9 (17)	105.8 (34)	111.3 (19)	116.0 (26)	114.0 (45)
139.5 (10)	135.7 (20)	137.0 (30)	138.3 (9)	136.8 (15)	137.3 (24)
181.0 (1)	175.9 (11)	176.3 (12)	178.7 (6)	163.0 (2)	174.7 (8)
239.2 (2)	270.0 (1)	249.6 (3)	- - -	221.0 (1)	221.0 (1)
330.5 (1)	303.0 (1)	316.8 (2)	- - -	- - -	- - -
461.0 (1)	- - -	461.0 (1)	- - -	- - -	- - -
510.3 (2)	- - -	510.3 (2)	- - -	- - -	- - -

APPENDIX II

II (Cont'd)

Length (m.)	Average Whole Weight (G				
	BIG BEAR CAVE POND			INDIAN BAY BIG POND	
Male	Female	Combined	Male	Female	Combined
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
---	---	---	---	---	---
41.0 (3)	42.5 (7)	42.1 (10)	---	---	---
54.8 (19)	55.0 (25)	54.9 (44)	---	---	---
73.5 (8)	74.6 (17)	74.3 (25)	76.4 (4)	74.2 (2)	75.7 (6)
109.0 (2)	104.5 (2)	106.8 (4)	99.6 (12)	99.7 (7)	99.6 (19)
129.3 (2)	122.6 (4)	124.8 (6)	127.8 (14)	122.9 (14)	125.3 (28)
178.6 (3)	---	178.6 (3)	160.9 (9)	168.5 (8)	164.5 (17)
229.8 (5)	226.1 (6)	227.8 (11)	220.1 (4)	194.2 (6)	204.5 (10)
271.6 (5)	252.8 (2)	266.2 (7)	241.9 (5)	263.0 (1)	245.4 (6)
303.0 (2)	274.1 (1)	293.3 (3)	308.7 (3)	294.2 (2)	302.9 (5)
379.6 (3)	468.7 (3)	424.2 (6)	368.9 (3)	409.0 (1)	379.9 (4)
537.0 (1)	406.0 (1)	471.5 (2)	508.0 (1)	538.5 (1)	523.3 (2)
549.0 (1)	---	549.0 (1)	560.5 (1)	---	560.5 (1)
---	---	---	558.3 (1)	---	558.3 (1)
---	---	---	703.8 (1)	---	703.8 (1)
---	---	---	---	---	---
---	---	---	---	---	---

11

ght (Gm.)

INDIAN RIVER (Stream)			INDIAN RIVER (Sea-Run)		
Male	Female	Combined	Male	Female	Combined
5.5 (1)	- - -	5.5 (1)	- - -	- - -	- - -
7.9 (1)	8.8 (2)	8.5 (3)	- - -	- - -	- - -
16.2 (4)	15.5 (2)	16.0 (6)	- - -	- - -	- - -
23.5 (24)	22.8 (11)	23.3 (35)	- - -	- - -	- - -
36.9 (14)	31.3 (11)	34.4 (25)	- - -	- - -	- - -
48.4 (7)	43.1 (3)	46.8 (10)	- - -	- - -	- - -
61.4 (6)	70.0 (5)	65.3 (11)	- - -	- - -	- - -
- - -	- - -	- - -	- - -	- - -	- - -
133.3 (2)	126.7 (2)	130.0 (4)	- - -	- - -	- - -
- - -	- - -	- - -	156.0 (1)	- - -	156.0 (1)
- - -	- - -	- - -	201.3 (1)	205.5 (1)	203.4 (2)
- - -	- - -	- - -	254.9 (2)	- - -	254.9 (2)
- - -	- - -	- - -	316.0 (1)	310.9 (3)	312.2 (4)
- - -	- - -	- - -	361.8 (3)	363.5 (5)	362.9 (8)
- - -	- - -	- - -	- - -	429.0 (1)	429.0 (1)
- - -	- - -	- - -	557.5 (1)	- - -	557.5 (1)
- - -	- - -	- - -	- - -	- - -	- - -
- - -	- - -	- - -	- - -	- - -	- - -
- - -	- - -	- - -	- - -	- - -	- - -
- - -	- - -	- - -	- - -	1085.6 (1)	1085.6 (1)

APPENDIX II

e 12.

Calculated length - weight whole relationships for speckled trout from various localities in

og Regression Form	Exponential Form	Standard Error		Log Re
INDIAN RIVER (Stream)				
Log W = 2.5608 Log L - 1.4175	$W = .0382\ L^{2.5608}$	9.31	Male	Log W
le Log W = 2.6945 Log L - 1.5919	$W = .0256\ L^{2.6945}$	6.92	Female	Log W
ined Log W = 2.5330 Log L - 1.3878	$W = .0410\ L^{2.5330}$	8.52	Combined	Log W
STEPHENS' POND				
Log W = 3.0563 Log L - 1.9815	$W = .0104\ L^{3.0563}$	4.77	Male	Log W
le Log W = 2.8157 Log L - 1.6675	$W = .0215\ L^{2.8157}$	8.88	Female	Log W
ined Log W = 2.8844 Log L - 1.7586	$W = .0174\ L^{2.8844}$	6.27	Combined	Log W
THOMAS' POND				
Log W = 3.2444 Log L - 2.2326	$W = .0059\ L^{3.2444}$	8.15	Male	Log W
le Log W = 2.7852 Log L - 1.6224	$W = .0239\ L^{2.7852}$	10.16	Female	Log W
ined Log W = 3.1508 Log L - 2.1165	$W = .0077\ L^{3.1508}$	10.12	Combined	Log W
INDIAN BAY BIG POND				
Log W = 2.8865 Log L - 1.7901	$W = .0162\ L^{2.8865}$	29.18	Male	Log
le Log W = 3.0803 Log L - 2.0600	$W = .0087\ L^{3.0803}$	27.45	Female	Log
ined Log W = 2.9202 Log L - 1.8301	$W = .0148\ L^{2.9202}$	34.27	Combined	Log

calities in Newfoundland (with corresponding standard errors of estimate).

	Log Regression Form	Exponential Form	Standard Error
BERRY HILL POND			
)	Log W = 2.9983 Log L - 1.9229	$W = .0119\ L^{2.9983}$	8.20
ıle	Log W = 2.9137 Log L - 1.8406	$W = .0144\ L^{2.9137}$	4.01
)ined	Log W = 2.9642 Log L - 1.8882	$W = .0129\ L^{2.9642}$	9.01
ANGLE POND			
ə	Log W = 3.2130 Log L - 2.1631	$W = .0069\ L^{3.2130}$	20.92
ale	Log W = 3.0175 Log L - 1.9251	$W = .0119\ L^{3.0175}$	13.69
bined	Log W = 3.1617 Log L - 2.0972	$W = .0080\ L^{3.1617}$	23.87
BIG BEAR CAVE POND			
.e	Log W = 2.8987 Log L - 1.7851	$W = .0164\ L^{2.8987}$	23.62
nale	Log W = 2.8482 Log L - 1.7289	$W = .0187\ L^{2.8482}$	40.11
mbined	Log W = 2.8637 Log L - 1.7401	$W = .0182\ L^{2.8637}$	15.67
INDIAN RIVER (Sea-Run)			
le	Log W = 3.1337 Log L - 2.1606	$W = .0069\ L^{3.1337}$	10.79
nale	Log W = 3.3597 Log L - 2.4992	$W = .0032\ L^{3.3597}$	26.65
mbined	Log W = 3.2893 Log L - 2.3901	$W = .0041\ L^{3.2893}$	18.77

APPENDIX 11

13.

Calculated length - weight whole relationship for speckled trout fr

Length (Cm.)	Calculated Average Whole Weight (G						
	BERRY HILL POND			STEPHENS' POND			
	Male	Female	Combined	Male	Female	Combined	M
5	14.0	- - -	14.0	- - -	- - -	- - -	1
5	23.5	22.9	23.4	23.8	26.7	25.7	2
5	36.6	35.3	36.2	37.4	40.4	39.4	3
5	53.9	51.4	53.0	55.4	58.1	57.1	5
5	75.9	71.6	74.4	78.5	80.2	79.4	8
5	103.1	96.6	100.8	107.4	106.9	106.8	11
5	136.2	126.6	132.7	142.7	138.9	139.5	15
5	175.8	162.1	170.7	- - -	176.4	178.2	20
5	- - -	203.4	215.2	- - -	219.8	223.2	25
5	- - -	- - -	- - -	- - -	269.8	275.4	32
5	- - -	- - -	- - -	- - -	- - -	- - -	40
5	- - -	- - -	- - -	- - -	- - -	- - -	49

APPENDIX II

ıip for speckled trout from various localities in Newfoundland.

ı Average Whole Weight (Gm.)

	ANGLE POND			THOMAS' POND		
ɔmbined	Male	Female	Combined	Male	Female	Combined
- - -	13.3	14.5	13.7	- - -	- - -	- - -
25.7	23.3	24.5	23.8	- - -	- - -	- - -
39.4	37.4	38.4	38.0	34.7	- - -	35.2
57.1	56.6	56.6	57.1	52.7	59.2	52.9
79.4	81.7	79.8	81.9	76.3	81.3	75.8
106.8	113.6	108.7	113.2	106.4	108.1	104.7
139.5	153.0	143.9	151.8	143.7	140.2	140.3
178.2	201.0	186.0	198.6	189.4	177.5	183.4
223.2	258.3	235.4	254.1	- - -	220.7	234.5
275.4	326.3	293.2	319.9	- - -	- - -	- - -
- - -	405.7	- - -	396.2	- - -	- - -	- - -
- - -	497.5	- - -	484.3	- - -	- - -	- - -

APPENDIX II

E 13 (Cont'd)

Length (Cm.)	Calculated Average Whole Weight (Gm						
	BIG BEAR CAVE POND			INDIAN BAY BIG POND			
	Male	Female	Combined	Male	Female	Combined	Ma
5	- - -	- - -	- - -	- - -	- - -	- - -	4
5	- - -	- - -	- - -	- - -	- - -	- - -	9
5	- - -	- - -	- - -	- - -	- - -	- - -	16
5	- - -	- - -	- - -	- - -	- - -	- - -	24
5	38.5	38.3	38.9	- - -	- - -	- - -	36
5	56.0	55.3	56.2	- - -	- - -	- - -	50
5	77.9	76.5	78.0	74.3	70.3	74.8	67
5	104.8	102.4	104.6	99.9	96.4	100.9	88
5	137.2	133.5	136.5	130.6	128.3	132.3	111
5	175.5	170.0	174.0	166.9	166.9	169.5	- -
5	220.1	212.2	227.9	209.0	211.9	212.9	- -
5	271.7	261.1	268.1	257.9	265.3	263.3	- -
5	330.7	316.6	325.4	313.6	326.8	320.9	- -
5	397.6	379.5	390.4	376.7	397.5	386.4	- -
5	472.6	449.8	463.1	447.5	477.5	459.8	- -
5	556.2	- - -	543.9	526.2	- - -	541.9	- -
5	- - -	- - -	- - -	614.1	- - -	633.3	- -
5	- - -	- - -	- - -	710.3	- - -	733.8	- -
5	- - -	- - -	- - -	- - -	- - -	- - -	- -
5	- - -	- - -	- - -	- - -	- - -	- - -	- -

IX 11

Whole Weight (Gm.)					
INDIAN RIVER (Stream)			INDIAN RIVER (Sea-Run)		
Male	Female	Combined	Male	Female	Combined
4.7	- - -	4.8	- - -	- - -	- - -
9.3	8.3	9.4	- - -	- - -	- - -
16.0	14.6	16.0	- - -	- - -	- - -
24.9	23.4	24.8	- - -	- - -	- - -
36.4	34.8	36.1	- - -	- - -	- - -
50.5	49.2	50.1	- - -	- - -	- - -
67.7	67.0	66.9	- - -	- - -	- - -
88.0	88.2	86.7	- - -	- - -	- - -
111.6	113.3	109.6	- - -	- - -	- - -
- - -	- - -	- - -	156.9	- - -	152.2
- - -	- - -	- - -	200.4	192.8	196.7
- - -	- - -	- - -	251.7	246.1	250.0
- - -	- - -	- - -	311.1	309.0	312.3
- - -	- - -	- - -	379.6	382.5	384.9
- - -	- - -	- - -	457.4	467.1	467.9
- - -	- - -	- - -	545.9	564.5	563.2
- - -	- - -	- - -	- - -	675.4	671.6
- - -	- - -	- - -	- - -	800.2	792.7
- - -	- - -	- - -	- - -	940.6	926.5
- - -	- - -	- - -	- - -	1098.0	1080.0

APPENDIX II

s 14.

Calculated length - weight gutted relationships for speckled trout from various localities

Log Regression Form	Exponential Form	Standard Error	Lo
INDIAN RIVER (Stream)			
Log W = 2.5784 Log L - 1.4737	$W = .0336\ L^{2.5784}$	8.28	Male
Log W = 2.6595 Log L - 1.5948	$W = .0219\ L^{2.6595}$	6.40	Female
Log W = 2.5329 Log L - 1.4269	$W = .0293\ L^{2.5329}$	7.57	Combir
STEPHENS' POND			
Log W = 3.2317 Log L - 2.2551	$W = .0056\ L^{3.2317}$	6.70	Male
Log W = 2.7498 Log L - 1.6464	$W = .0226\ L^{2.7498}$	5.22	Female
Log W = 2.8521 Log L - 1.7809	$W = .0166\ L^{2.8521}$	4.07	Combi
THOMAS' POND			
Log W = 3.3196 Log L - 2.3790	$W = .0042\ L^{3.3196}$	7.43	Male
Log W = 2.7891 Log L - 1.6797	$W = .0209\ L^{2.7891}$	8.32	Femal
Log W = 3.2194 Log L - 2.2577	$W = .0056\ L^{3.2194}$	9.13	Combi
INDIAN BAY BIG POND			
Log W = 2.8244 Log L - 1.7440	$W = .0180\ L^{2.8244}$	36.10	Male
Log W = 2.9178 Log L - 1.8837	$W = .0131\ L^{2.9178}$	12.46	Femal
Log W = 2.8384 Log L - 1.7689	$W = .0170\ L^{2.8384}$	33.98	Combi

.ocalities in Newfoundland (with corresponding standard errors of estimate).

	Log Regression Form	Exponential Form	Standard Error
BERRY HILL POND			
Male	Log W = 2.9052 Log L - 1.8462	$W = .0143\ L^{2.9052}$	4.72
Female	Log W = 2.8820 Log L - 1.8415	$W = .0144\ L^{2.8820}$	4.58
Combined	Log W = 2.9025 Log L - 1.8536	$W = .0140\ L^{2.9025}$	4.46
ANGLE POND			
Male	Log W = 3.2014 Log L - 2.1983	$W = .0063\ L^{3.2014}$	18.63
Female	Log W = 2.9952 Log L - 1.9463	$W = .0113\ L^{2.9952}$	11.87
Combined	Log W = 3.1380 Log L - 2.1163	$W = .0077\ L^{3.1380}$	21.22
BIG BEAR CAVE POND			
Male	Log W = 2.8538 Log L - 1.7632	$W = .0173\ L^{2.8538}$	11.84
Female	Log W = 2.8008 Log L - 1.7070	$W = .0196\ L^{2.8008}$	34.67
Combined	Log W = 2.8184 Log L - 1.7180	$W = .0191\ L^{2.8184}$	14.99
INDIAN RIVER (Sea-Run)			
Male	Log W = 3.1408 Log L - 2.1967	$W = .0064\ L^{3.1408}$	8.88
Female	Log W = 3.0988 Log L - 2.1373	$W = .0073\ L^{3.0988}$	21.40
Combined	Log W = 3.1536 Log L - 2.2183	$W = .0061\ L^{3.1536}$	23.24

APPENDIX II

Table 15.

Length - Weight gutted relationship for speckled trout fro

Length (cm.)	Average Gutted Weight (G					
	BERRY HILL POND			STEPHENS' POND		
	Male	Female	Combined	Male	Female	Combined
5	12.9 (1)	- - -	12.9 (1)	- - -	- - -	- - -
5	22.5 (4)	20.1 (2)	21.0 (6)	19.0 (1)	23.0 (1)	21.0 (2)
5	35.4 (18)	35.3 (9)	35.4 (27)	29.7 (1)	36.9 (3)	35.1 (4)
5	47.7 (17)	47.0 (7)	47.5 (24)	55.6 (14)	53.9 (14)	54.8 (28)
5	74.5 (7)	65.2 (5)	70.6 (12)	72.9 (16)	68.3 (20)	69.8 (36)
5	95.0 (4)	86.0 (3)	91.1 (7)	98.0 (6)	87.3 (11)	91.1 (17)
5	112.0 (1)	107.9 (4)	108.7 (5)	120.7 (3)	114.8 (12)	116.0 (15)
5	156.7 (1)	- - -	156.7 (1)	- - -	- - -	- - -
5	- - -	190.1 (1)	190.1 (1)	- - -	184.0 (1)	184.0 (1)
5	- - -	- - -	- - -	- - -	237.5 (1)	237.5 (1)
5	- - -	- - -	- - -	- - -	- - -	- - -
5	- - -	- - -	- - -	- - -	- - -	- - -

DIX II

ed trout from various localities in Newfoundland.

ed Weight (Gm.)

ANGLE POND			THOMAS' POND		
Male	Female	Combined	Male	Female	Combined
11.5 (1)	15.5 (1)	13.5 (2)	- - -	- - -	- - -
21.5 (2)	19.0 (1)	20.7 (3)	- - -	- - -	- - -
34.4 (2)	35.8 (3)	35.2 (5)	26.3 (2)	- - -	26.3 (2)
51.8 (2)	47.5 (2)	49.7 (4)	53.0 (1)	47.3 (2)	49.2 (3)
81.7 (7)	68.8 (5)	76.3 (12)	72.7 (10)	81.0 (12)	77.1 (22)
96.6 (17)	94.8 (17)	95.7 (34)	99.0 (19)	102.2 (26)	100.9 (45)
126.0 (10)	122.2 (20)	123.5 (30)	125.4 (9)	121.9 (15)	123.2 (24)
161.5 (1)	156.3 (11)	156.7 (12)	161.8 (6)	146.8 (2)	158.0 (8)
208.3 (2)	238.8 (1)	218.4 (3)	- - -	199.0 (1)	199.0 (1)
295.5 (1)	267.0 (1)	281.3 (2)	- - -	- - -	- - -
409.0 (1)	- - -	409.0 (1)	- - -	- - -	- - -
447.4 (2)	- - -	447.4 (1)	- - -	- - -	- - -

APPENDIX II

15 (Cont'd)

Length (Cm.)	Average Gutted Weight (				
	BIG BEAR CAVE POND			INDIAN BAY BIG POND	
	Male	Female	Combined	Male	Female	Combined
[illegible]	- - -	- - -	- - -	- - -	- - -	- - -
[illegible]	- - -	- - -	- - -	- - -	- - -	- - -
[illegible]	- - -	- - -	- - -	- - -	- - -	- - -
[illegible]	- - -	- - -	- - -	- - -	- - -	- - -
[illegible]	37.7 (3)	38.8 (7)	38.8 (10)	- - -	- - -	- - -
[illegible]	50.8 (19)	51.4 (25)	51.1 (44)	- - -	- - -	- - -
[illegible]	67.9 (8)	68.5 (17)	68.6 (25)	71.2 (4)	66.8 (2)	69.7 (6)
[illegible]	99.3 (2)	95.5 (2)	97.4 (4)	91.2 (12)	91.9 (7)	91.5 (19)
[illegible]	119.4 (2)	110.9 (4)	113.7 (6)	116.6 (14)	111.7 (14)	114.2 (28)
[illegible]	165.8 (3)	- - -	165.8 (3)	141.8 (9)	150.1 (8)	145.7 (17)
[illegible]	210.3 (5)	204.2 (6)	207.0 (11)	202.2 (4)	176.2 (6)	186.6 (10)
[illegible]	248.9 (5)	231.1 (2)	243.8 (7)	238.2 (5)	237.0 (1)	225.5 (6)
[illegible]	278.5 (2)	237.5 (1)	264.8 (3)	281.6 (3)	270.5 (2)	277.1 (5)
[illegible]	343.7 (3)	416.1 (3)	379.8 (6)	336.6 (3)	333.1 (1)	335.7 (4)
[illegible]	448.0 (1)	365.5 (1)	406.8 (2)	455.3 (1)	430.5 (1)	442.9 (2)
[illegible]	501.5 (1)	- - -	501.5 (1)	511.2 (1)	- - -	511.2 (1)
[illegible]	- - -	- - -	- - -	457.2 (1)	- - -	457.2 (1)
[illegible]	- - -	- - -	- - -	635.8 (1)	- - -	635.8 (1)
[illegible]	- - -	- - -	- - -	- - -	- - -	- - -
[illegible]	- - -	- - -	- - -	- - -	- - -	- - -

X II

Weight (Gm.)

INDIAN RIVER (Stream)			INDIAN RIVER (Sea-Run)		
Male	Female	Combined	Male	Female	Combined
5.0 (1)	- - -	5.0 (1)	- - -	- - -	- - -
7.1 (1)	7.9 (2)	7.6 (3)	- - -	- - -	- - -
15.0 (4)	14.3 (2)	14.8 (6)	- - -	- - -	- - -
21.8 (24)	21.2 (11)	21.6 (35)	- - -	- - -	- - -
34.2 (14)	28.7 (11)	31.8 (25)	- - -	- - -	- - -
44.6 (7)	38.4 (3)	42.8 (10)	- - -	- - -	- - -
56.6 (6)	61.3 (5)	58.7 (11)	- - -	- - -	- - -
- - -	- - -	- - -	- - -	- - -	- - -
122.8 (2)	113.6 (2)	118.2 (4)	- - -	- - -	- - -
- - -	- - -	- - -	143.0 (1)	- - -	143.0 (1)
- - -	- - -	- - -	192.5 (1)	196.0 (1)	194.3 (2)
- - -	- - -	- - -	245.5 (2)	- - -	245.5 (2)
- - -	- - -	- - -	296.5 (1)	291.9 (3)	293.1 (4)
- - -	- - -	- - -	344.5 (3)	340.9 (5)	342.3 (8)
- - -	- - -	- - -	- - -	410.0 (1)	410.0 (1)
- - -	- - -	- - -	518.7 (1)	- - -	518.7 (1)
- - -	- - -	- - -	- - -	- - -	- - -
- - -	- - -	- - -	- - -	- - -	- - -
- - -	- - -	- - -	- - -	- - -	- - -
- - -	- - -	- - -	- - -	909.0 (1)	909.0 (1)

APPENDIX II

16.

Calculated Length - weight gutted relationship for speckled trout f

length	Calculated Average Gutted Weight (					
	BERRY HILL POND			STEPHENS' POND		
Male	Female	Combined	Male	Female	Combined	Mal
13.4	- - -	13.1	- - -	- - -	- - -	12.
22.2	21.1	21.6	19.7	23.7	22.5	20.
34.1	32.4	33.2	31.8	35.6	34.3	33.
49.5	46.9	48.3	48.3	50.7	49.6	50.
69.0	65.2	67.3	69.8	69.4	68.7	72.
92.9	87.6	90.6	97.2	92.0	92.0	101.
121.6	114.4	118.6	131.2	118.8	119.8	136.
155.7	146.2	151.8	- - -	185.9	190.7	178.
- - -	183.0	190.4	- - -	227.1	234.7	229.
- - -	- - -	- - -	- - -	- - -	- - -	289.
- - -	- - -	- - -	- - -	- - -	- - -	359.
- - -	- - -	- - -	- - -	- - -	- - -	440.

trout from various localities in Newfoundland.

eight (Gm.)

ANGLE POND			THOMAS' POND		
Male	Female	Combined	Male	Female	Combined
12.0	13.1	12.4	- - -	- - -	- - -
20.8	22.1	21.4	- - -	- - -	- - -
33.5	34.4	34.1	30.3	- - -	30.6
50.5	50.6	51.1	46.4	52.4	46.4
72.8	71.3	73.1	67.8	72.1	66.9
101.1	96.8	100.8	95.4	96.0	93.1
136.1	127.8	134.9	129.7	124.3	125.5
178.6	164.9	176.1	172.0	157.5	165.0
229.3	208.4	225.0	- - -	195.8	212.1
289.5	259.1	282.7	- - -	- - -	- - -
359.5	- - -	349.6	- - -	- - -	- - -
440.7	- - -	427.8	- - -	- - -	- - -

APPENDIX II

16 (Cont'd).

Length (Cm.)	Calculated Average Gutted Weight (Gm.)							
	BIG BEAR CAVE POND			INDIAN BAY BIG POND			INDIAN R	
	Male	Female	Combined	Male	Female	Combined	Male	Fe
55	- - -	- - -	- - -	- - -	- - -	- - -	4.3	-
55	- - -	- - -	- - -	- - -	- - -	- - -	8.5	
55	- - -	- - -	- - -	- - -	- - -	- - -	14.6	
55	- - -	- - -	- - -	- - -	- - -	- - -	22.9	
55	35.9	35.5	36.3	- - -	- - -	- - -	33.5	
55	51.9	50.9	52.1	- - -	- - -	- - -	46.7	
55	71.9	70.1	71.9	69.0	65.6	67.8	62.6	
55	96.3	93.4	96.0	92.1	88.5	90.7	81.6	
55	125.4	121.1	124.7	119.7	116.1	118.0	103.6	
55	159.9	153.6	158.4	152.2	148.7	150.3	- - -	
55	199.8	191.1	197.4	189.6	186.7	187.5	- - -	
55	245.9	234.3	242.3	232.9	230.9	230.5	- - -	
55	298.3	283.2	293.4	282.0	281.3	279.4	- - -	
55	357.6	338.4	350.9	337.5	338.7	334.6	- - -	
55	423.9	399.9	415.1	399.3	403.0	396.3	- - -	
55	497.7	- - -	486.2	468.0	- - -	464.7	- - -	
55	- - -	- - -	- - -	544.3	- - -	540.9	- - -	
55	- - -	- - -	- - -	627.5	- - -	624.0	- - -	
55	- - -	- - -	- - -	- - -	- - -	- - -	- - -	
55	- - -	- - -	- - -	- - -	- - -	- - -	- - -	

ed Weight (Gm.)

INDIAN RIVER (Stream)			INDIAN RIVER (Sea-Run)		
Male	Female	Combined	Male	Female	Combined
4.3	- - -	4.4	- - -	- - -	- - -
8.5	7.7	8.6	- - -	- - -	- - -
14.6	13.4	14.6	- - -	- - -	- - -
22.9	21.2	22.7	- - -	- - -	- - -
33.5	31.5	33.0	- - -	- - -	- - -
46.7	44.3	45.7	- - -	- - -	- - -
62.6	60.1	61.1	- - -	- - -	- - -
81.6	78.9	79.2	- - -	- - -	- - -
103.6	100.9	100.1	- - -	- - -	- - -
- - -	- - -	- - -	147.7	- - -	146.4
- - -	- - -	- - -	188.7	188.6	187.3
- - -	- - -	- - -	237.1	236.2	235.3
- - -	- - -	- - -	293.4	291.4	291.6
- - -	- - -	- - -	358.2	354.7	356.3
- - -	- - -	- - -	431.6	426.5	429.4
- - -	- - -	- - -	515.3	507.9	513.5
- - -	- - -	- - -	- - -	599.4	607.5
- - -	- - -	- - -	- - -	700.8	712.4
- - -	- - -	- - -	- - -	813.4	829.0
- - -	- - -	- - -	- - -	938.3	958.8

APPENDIX II

17.

Variation in the coefficients of condition K and Kc with length (K is calculated from empirical length - weight relationships).

Length (cm.)	Mean Condition Factor									
	INDIAN RIVER (Stream)				STEPHENS' POND				THOMAS' POND	
	BERRY HILL POND				ANGLE POND					
	K	Kc	K	Kc	K	Kc	K	Kc	K	Kc
	1.67	1.66	---	---	---	---	---	---	---	---
	1.42	1.48	---	---	---	---	---	---	---	---
	1.20	1.34	1.27	1.17	---	---	1.27	1.15	---	---
	1.11	1.24	1.11	1.17	1.29	1.29	1.26	1.18	---	---
	1.07	1.16	1.17	1.16	1.18	1.27	1.14	1.22	1.06	1.13
	1.10	1.09	1.20	1.16	1.27	1.25	1.19	1.25	1.10	1.16
	---	1.04	1.15	1.16	1.24	1.23	1.30	1.27	1.30	1.18
	1.14	0.99	1.18	1.15	1.21	1.22	1.22	1.29	1.30	1.20
	---	0.95	1.08	1.15	1.19	1.21	1.21	1.32	1.21	1.22
	---	---	1.21	1.15	---	1.20	1.21	1.33	1.24	1.23
	---	---	1.20	1.14	1.33	1.19	1.33	1.35	1.22	1.25
	---	---	---	---	1.18	1.18	1.36	1.37	---	---
	---	---	---	---	---	---	1.56	1.38	---	---
	---	---	---	---	---	---	1.53	1.40	---	---
	---	---	---	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---	---
	---	---	---	---	---	---	---	---	---	---

II

om empirical length - weight relationships and Kc is a modified coefficient calculated from calculated

Factor							
OMAS' POND				INDIAN BAY BIG POND			
		BIG BEAR CAVE POND				INDIAN RIVER (Sea-Run)	
K	Kc	K	Kc	K	Kc	K	Kc
--	---	---	---	---	---	---	---
--	---	---	---	---	---	---	---
--	---	---	---	---	---	---	---
--	---	---	---	---	---	---	---
.06	1.13	1.23	1.25	---	---	---	---
.10	1.16	1.16	1.23	---	---	---	---
.30	1.18	1.14	1.21	1.15	1.16	---	---
.30	1.20	1.17	1.20	1.14	1.15	---	---
.21	1.22	1.09	1.18	1.10	1.15	---	---
.24	1.23	1.15	1.17	1.16	1.14	1.13	1.02
.22	1.25	1.17	1.16	1.12	1.13	1.07	1.05
---	---	1.16	1.15	1.07	1.13	1.04	1.07
---	---	1.10	1.14	1.08	1.12	1.09	1.09
---	---	1.28	1.13	1.09	1.12	1.07	1.11
---	---	1.20	1.12	1.27	1.11	1.02	1.13
---	---	1.20	1.11	1.11	1.11	1.11	1.15
---	---	---	---	1.03	1.11	---	1.17
---	---	---	---	1.09	1.10	---	1.18
---	---	---	---	---	---	---	1.20
---	---	---	---	---	---	1.27	1.22